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# Science & Technology

## USSR: Physics & Mathematics

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### CONTENTS

31 MAY 1989

#### Acoustics

- Temperature Anomalies of Dispersion and Absorption of Sound Near Phase Transition Points at Low Temperatures  
 [N. V. Shchedrina, M. I. Shchedrin; *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA*, Vol 32 No 1, Jan 89] ..... 1
- Interaction Between Laser Radiation and Diamond Films  
 [V. P. Ageyev, L. L. Buylov, et al.; *DOKLADY AKADEMII NAUK SSSR*, Vol 303 No 3, Nov 88] ..... 1

#### Crystals, Laser Glasses, Semiconductors

- Synthesis of Bi-Alkali Photocathodes by Molecular Ray Epitaxy Method  
 [V. V. Balanyuk, I. A. Dubovoy, et al.; *ZHURNAL TEKHNIЧЕСКОY FIZIKI*, Vol 59 No 1, Jan 89] ..... 2
- Influence of Thermal Processing on Properties of Epitaxial Layers of GaAs Alloyed With Tin  
 [I. A. Bobrovnikova, M. D. Vilisova, et al.; *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA*, Vol 32 No 1, Jan 89] ..... 2

#### Gas Dynamics

- Entry of Freely Expanding Gas Jet Into Circular Orifice in Transverse Barrier  
 [A. M. Bishayev, Ye. F. Limar, et al.; *ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI*, Vol 29 No 2, Feb 89] ..... 3

#### Fluid Dynamics

- Computer Experiment Pertaining to Theory of Surface Wave With Finite Amplitude  
 [K. I. Babenko (deceased), V. Yu. Petrovich, et al.; *DOKLADY AKADEMII NAUK SSSR*, Vol 302 No 4, Oct 88] ..... 4
- Magnetic Superfluidity In He-3  
 [E. B. Sonin; *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI*, Vol 94 No 9, Sep 88] ..... 4

#### Lasers

- Spectral Characteristics of Injection Laser With Intracavity Absorption Cell  
 [E. M. Belenov, V. L. Velichanskiy, et al.; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 5
- Synchronous Pumping of Organic-Dye Jet Lasers With Sinusoidally Modulated Ar-Laser Radiation  
 [G. I. Ray, B. P. Ustinov, et al.; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 5
- Performance of Gd-Sc-Al: Cr, Nd Garnet Laser  
 [A. A. Danilov, A. L. Denisov, et al.; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 5
- New Possibility of Diatomic Dimer Lasers With Solar Pumping  
 [A. L. Golger, I. I. Klimovskiy, et al.; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 6
- Adaptive Methods of Light-Beam Shaping Under Conditions of Speckle-Modulation of Scattered Field  
 [M. A. Vorontsov, I. A. Kudryashov, et al.; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 6
- Laser With Stimulated-Brillouin-Scattering Mirror Switchable by Intrinsic Starter Radiation  
 [P. P. Pashinin, Ye. I. Shklovskiy; *KVANTOVAYA ELEKTRONIKA*, Vol 15 No 9, Sep 88] ..... 6
- Anomalous Formation of Defects in V<sub>2</sub>O<sub>3</sub> During Laser Treatment  
 [A. V. Manukhin, V. A. Stepanov, et al.; *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA*, No 9, Sep 88] ..... 7
- Generation of Solid-State Lasers With Self-Pumping Reversed Wave Front Cavity  
 [V. A. Berenberg, A. Ye. Vasilyev; *OPTIKA I SPEKTROSKOPIYA*, Vol 65 No 3, Sep 88] ..... 7
- Shortening of Laser Pulse by Nonlinearly Absorbing Media  
 [E. V. Bezlepko, M. V. Bogdanova, et al.; *OPTIKA I SPEKTROSKOPIYA*, Vol 65 No 3, Sep 88] ..... 7

UV Generation During Pumping of He-Cd Mixture by Electron Beam [S. P. Bugayev, F. G. Goryunov, et al.; OPTIKA I SPEKTROSKOPIYA, Vol 65 No 3, Sep 88]	7
Increasing Sensitivity of High-Resolution Intracavity Spectrometers by Use of Continuously Tunable Lasers [S. F. Lukyachenko, A. M. Solodov; ZHURNAL PRIKLADNOY SPEKTROSKOPII, Vol 49 No 2, Aug 88]	8
Use of XeCl and KrF Excimer Lasers for Diagnostic Flame Analysis by Method of Spontaneous-Raman-Scattering Spectroscopy [A. N. Malov, S. Yu. Fedorov; FIZIKA GORENIYA I VZRYVA, Vol 24 No 4, Jul-Aug 88]	8

## Nuclear Physics

Microscopic Theory of Spectrum of Single-Particle Excitations of Normal Fermi Systems [V. A. Khodel, V. R. Shaginyan; YADERNAYA FIZIKA, Vol 49 No 1, Jan 89]	9
Possible Resolution of 'Spin Crisis' in Parton Model [M. Anselmino, B. L. Ioffe, et al.; YADERNAYA FIZIKA, Vol 49 No 1, Jan 89]	9
Theory of Photon Interferometry for Quark-Gluon Plasma [A. N. Makhlin; YADERNAYA FIZIKA, Vol 49 No 1, Jan 89]	9
Thermal Autooscillations and Autowaves in Superconductor Connected to External Circuit [Yu. M. Lvovskiy; ZHURNAL TEKHNIЧЕСКОY FIZIKI, Vol 58 No 11, Nov 88]	9
Anomalies in Radiation Pattern of Channeled Electrons [A. O. Aganyants, Yu. A. Vartanov, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 10 Oct 88]	10
Multiphonon States of One-Dimensional Chain With Anharmonicity [A. N. Orayevskiy, M. Yu. Sudakov; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88]	10
Stochastic Aggregation of Particles Upon Their Pulsed Excitation and Subsequent Recombination in Fractal Systems and in Homogeneous Systems [I. M. Sokolov; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88]	10
Acoustic Muon-Spin Resonance in Ferromagnetic Materials [Yu. M. Belousov, V. P. Smilga; DOKLADY AKADEMII NAUK SSSR, Vol 302 No 1, Sep 88]	11
Indirect Electron-Electron Interaction Through Solitons in Anharmonic Lattice [Yu. A. Izyumov, V. M. Laptev; DOKLADY AKADEMII NAUK SSSR, Vol 302 No 1, Sep 88]	11
Cold Compact and Cold Deformed Spontaneous Fission of $^{252}\text{Cf}$ [I. D. Alkhazov, A. V. Kuznetsov, et al.; YADERNAYA FIZIKA, Vol 48 No 3 (9), Sep 88]	11
Coefficient of Muon Adhesion to Helium [Ye. M. Gandyl, A. L. Zubarev; YADERNAYA FIZIKA, Vol 48 No 3 (9), Sep 88]	11
Search for Decay of Neutral Rho Meson Into Positive Pion Plus Negative Pion Plus Neutral Pion [I. B. Vasserman, V. B. Golubev, et al.; YADERNAYA FIZIKA, Vol 48 No 3 (9), Sep 88]	12
Compatibility of Small Neutrino Mass and Large Neutrino Magnetic Moment [M. B. Voloshin; YADERNAYA FIZIKA, Vol 48 No 3 (9), Sep 88]	12
Exactly Solvable Model of Field Theory With Tachyons [I. V. Barashenkov, B. S. Getmanov; YADERNAYA FIZIKA, Vol 48 No 3 (9), Sep 88]	12
Reconstruction of Energy Spectra of Neutrons Generated During Solar Flares on Basis of Electrons Produced in Decay of Those Neutrons [Ye. V. Kolomeyets, V. N. Sevostyanov, et al.; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA, No 4 (143), Jul-Aug 88]	12
Instability and Collapse of Solitons in Media With Defocusing Nonlinearity [Ye. A. Kuznetsov, S. K. Turitsyn; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 8, Aug 88]	13
Effect of Gravitation on Diffraction of Neutrons by Bent Single Crystal of Quartz [V. L. Alekseyev, Ye. G. Lapin, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 8, Aug 88]	13
Effect of Rest Mass of Neutrino and of Antineutrino on Their Scattering by $^{12}\text{C}_6$ Nucleus [N. V. Samsonenko, Chkhotu Lal Katkhat, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 7, Jul 88]	14
Nonstandard Formulation of Perturbation Theory for Green's Functions [M. N. Aliyev, V. S. Tagiyev; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 7, Jul 88]	14

Early Stages of Electrical Breakdown Initiated by Laser Radiation in Charged Glasses [A. I. Akishin, N. V. Zelikin, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 7, Jul 88]	14
Amplification of Magnetostatic Solitons by Drift Flux of Charge Carriers in Ferromagnetic-Semiconductor Structure [N. Ye. Vigdorchik, I. V. Ioffe; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, 26 Jun 88]	14

## Optics, Spectroscopy

Diffraction Inversion of Wave Front [Yu. A. Afinogenov, Yu. G. Pavlenko; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 11, Nov 88]	15
Precession Mechanisms of Light-Induced Quadrupole Moment of Ground State of Atoms With Superfine Structure in Weak Magnetic Field and Their Manifestations in Optical Characteristics [M. V. Krashenninnikov, V. S. Smirnov, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 11, Nov 88]	15
Detection of Photomodification of Silver Clusters Selective With Respect to Wavelength and Polarization [S. V. Karpov, A. K. Popov, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Nov 88]	15
Measurement of Diffraction Scattering of X-Rays at Glancing Angles of Incidence Using Position-Sensitive Detector [A. A. Lomov, D. V. Novikov, et al.; FIZIKA TVERDOGO TELA, Vol 30 No 10, Oct 88]	15
Algorithm for Increasing Measurement Accuracy in Shadow Method [V. A. Pilipovich, A. K. Yesman, et al.; VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-MATEMATYCHNYKH NAVUK, No 5, Sep-Oct 88]	16
Underwater Multichannel Fluorimeter for Marine Ecological Research [G. S. Karabashev, S. A. Khanayev; ZHURNAL PRIKLADNOY SPEKTROSKOPII, Vol 49 No 3, Sep 88]	16
Shift Selectivity of Holograms With Reference Speckle Wave [A. M. Darskiy, V. B. Markov; OPTIKA I SPEKTROSKOPIYA, Vol 65 No 3, Sep 88]	16
Exciton Absorption During Passage of Light Through AlGaAs Double Heterostructure With Quantum-Dimensional Layer Acting as Waveguide [R. P. Seysyan, A. A. Toropov, et al.; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, 12 Sep 88]	17
Formation of Ordered Structure in Albumin Film During Desiccation [Ye. G. Rapis; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, 12 Sep 88]	17
Frequency Autoconversion in and Reflectionless Propagation of Electromagnetic High-Frequency Pulse Under Breakdown Conditions [V. B. Gildenburg, V. A. Krupnov, et al.; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, 26 Sep 88]	17
Determination of Parameters of Thin-Film Fiber Optics [E. A. Arutyunyan, S. Kh. Galoyan, et al.; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, 26 Sep 88]	18
Asymptotic Model Describing Light-Scattering Characteristics of Fractal Clusters [V. N. Kuzmin, O. V. Moroz, et al.; DOKLADY AKADEMII NAUK SSSR, Vol 312 No 2, Sep 88]	18

## Plasma Physics

Rotational Instability of Charged Plasma in Crossed Perpendicular E/H Fields and Generation of Electrons of Anomalous High Energy [N. A. Kervlishvili; FIZIKA PLAZMY, Vol 15 No 2, Feb 89]	19
Radiation of Hard Electrons From Laser Plasma in 'Delfin' Apparatus [F. A. Nikolayev, S. F. Roslik, et al.; FIZIKA PLAZMY, Vol 15 No 2, Feb 89]	19
Optimal Experiment for Research on Semi-Self-Maintained Discharge [V. A. Ivanov, I. V. Makasyuk; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, Vol 31 No 10, Oct 88]	19
New Integral Equations for Systems With Coulomb Interaction [V. V. Belov; DOKLADY AKADEMII NAUK BSSR, Vol 32 No 10, Oct 88]	19
Breakdown of Jet of Molecular Vapor in Laser Irradiation of Nonmetallic Materials [V. S. Vorobyev, S. V. Maksimenko; TEPILOFIZIKA VYSOKIKH TEMPERATUR, Vol 26 No 5, Sep-Oct 88]	20

Plasma Condensation in Fluctuating Strong Magnetic Field [V. S. Gorbachev, S. R. Kelner; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88] .....	20
---	----

## Superconductivity

Distribution of Local Currents in Disordered Conductors [I. V. Lerner; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 95 No 1, Jan 89] .....	21
Polaron Theory of High-Temperature Superconductors [A. S. Aleksandrov; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 95 No 1, Jan 89] .....	21
Thermodynamic and Magnetic Properties of System of Superconducting Twinning Planes [A. A. Abrikosov, A. I. Buzdin, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 95 No 1, Jan 89] .....	21
Raman Light Scattering in $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ [Yu. S. Ponosov, G. A. Bolotin; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 10 Jan 89] .....	21
Raman Light Scattering in Monocrystals of Superconductors $\text{Ti-Ba-Cu-O}$ [L. V. Gasparov, V. D. Kulakovskiy, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 10 Jan 89] .....	22
Nonlinear Bisoliton Model of Superconductivity [A. S. Davydov; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI, No 9, Sep 88] .....	22
Phase Transition of Granular Superconductor Films [Ye. A. Antonova, V. L. Ruzinov; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Sep 88] .....	22
Acoustical Characteristics of $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ ( $x: 0,0.2$ ) and $\text{YBa}_2\text{Cu}_3\text{O}_y$ ( $y: 6,7$ ) and Anomalies in Their Lattice Vibration Spectra [V. I. Makarov, N. V. Zavaritskiy, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Sep 88] .....	23
Anisotropy of Electron-Paramagnetic-Resonance Absorption in Single Crystals of $\text{R-Ba-Cu-O}$ Superconductors (in Weak Magnetic Fields) [Yu. I. Vesnin, V. Ye. Istomin, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Sep 88] .....	23
Localization of Electrons at Type-2 Heterojunction [A. N. Baranov, A. A. Guseynov, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Sep 88] .....	23
Splitting of Energy Gap in Two-Dimensional Superconductor Without Inversion Center [V. M. Edelshteyn; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, 25 Sep 88] .....	24
Effect of Twinning on Superconducting Transition Temperature for Beta-( $\text{ET}$ ) $_2\text{X}$ Organic Metals [A. V. Zvarykina, M. V. Kartsovich, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88] .....	24
Quasiparticle Current in Superconductor-Semiconductor-Superconductor Sandwich [A. V. Tartakovskiy, M. V. Fistul; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 94 No 9, Sep 88] .....	24
Thermodynamics of Current States in Superconductors [Ye. K. Kudinov; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	25
Shielding of Electromagnetic Interactions in Superconductors [A. A. Matsutsin; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	25
Distribution of Oxygen Ions in Superconductor Ceramic [A. M. Khasanov, S. S. Tsarevskiy, et al.; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	25
Effect of Equilibrium Phase Composition on Superconductivity of Materials in $\text{Y}_2\text{O}_3\text{-BaO-CuO}$ System [Yu. Ya. Skolis, G. A. Chesnokov, et al.; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	26
Response of Valence Electrons in $\text{Nb}_3\text{Ge}$ Superconductor to Ion Displacements [S. V. Stolbov, M. N. Rabinovich; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	26
Moessbauer Spectroscopy of $(\text{Y,Eu})\text{Ba}_2\text{Cu}_3\text{O}$ [A. M. Khasanov, S. S. Tsarevskiy, et al.; FIZIKA TVERDOGO TELA, Vol 30 No 9, Sep 88] .....	26

Electron Tunneling Into Nonhomogeneous Superconductors [M. A. Belogolovskiy, A. I. Dyachenko; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 9, Sep 88]	27
Study of $U_2PtC_2$ Heavy-Fermion Superconductor With Use of Microjunctions [Yu. G. Naydok, I. K. Yanson, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 8, Aug 88]	27
Critical Parameters of $YBa_2Cu_3O_{7-d}$ Superconductor [Ya. V. Kopelevich, V. V. Lemanov, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 8, Aug 88]	27
Magnetic Structure of Anisotropic Type-II Superconductors [R. G. Mints; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 8, Aug 88]	28
Effect of Exposure of Nitrogen Vapor on Critical Superconducting Transition Temperature for $YBa_2Cu_3O_{7-d}$ High-Temperature Superconductor [A. I. Golovashkin, I. S. Levchenko, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 8, Aug 88]	28
Crystalline Structure of $LaBa_2Cu_3O_7$ Superconductor Compound [V. P. Glazkov, I. P. Zibrov, et al.; <i>ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI</i> , Vol 94 No 7, Jul 88]	28
Raman Scattering of Light in Monophase $YBa_2Cu_3O_{7-d}$ Ceramic [M. F. Limonov, Yu. F. Markov, et al.; <i>PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI</i> , 12 Jul 88]	29
Design of Superconducting Magnet System for Production of Nonuniform Magnetic Field Inside Analyzer of Static Mass-Spectrometer [A. S. Berdnikov, S. A. Vinogradova, et al.; <i>ZHURNAL TEKHNIЧЕСКОY FIZIKI</i> , Vol 58 No 7, Jul 88]	29
Structural Instability of $YBa_2Cu_3O_{7-d}$ High-Temperature Superconductor at Low Temperatures [O. V. Aleksandrov, O. M. Ivanenko, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	29
Nucleation of Low-Temperature $D_{4h}$ -Phase on Dislocations in $SrTiO_3$ Surface Layer [Ye. V. Balasheva, V. V. Lemanov, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	30
Spatial Distribution of Magnetic Induction in Superconducting Ceramic [V. M. Dzugutov, L. M. Fisher; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	30
Superconducting Nb-Rh-H Phases With Atomic Hydrogen-to-Metal Ratios Up to 2 [V. Ye. Antonov, T. Ye. Antonova, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	30
Superconductor Characteristics of New Si-Ag Telluride Glass Under High Pressures [A. A. Andreyev, I. V. Berman, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	31
Effect of Weak Electron Localization and of Electron-Electron Interaction in Amorphous Bismuth Films on Temperature Dependence of Their Electrical Conductivity [B. I. Belevtsev, Yu. F. Komnik, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	31
Possible Mechanism of High-Temperature Superconductivity (Critical Temperature Above 150 K) in Some Specimens of Y-Ba-Cu-O Ceramics [M. V. Krasinkova, B. Ya. Moyzhes; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	32
Characteristics of Magnetic Flux Entrapment in $YBa_2Cu_3O_{7-d}$ High-Temperature Superconductors in Weak Magnetic Field [Ye. V. Blinov, P. P. Kuleshov, et al.; <i>FIZIKA TVERDOGO TELA</i> , Vol 30 No 7, Jul 88]	32
Anomalous Absorption of Electromagnetic Field by $YBa_2Cu_3O_7$ and $HoBa_2Cu_3O_7$ Superconductor Ceramics [L. Ya. Kobelev, L. L. Nugayeva, et al.; <i>FIZIKA METALLOV I METALLOVEDENIYE</i> , Vol 66 No 1, Jul 88]	32
Spectra of Raman Scattering of Light in R-Ba-Cu-O Superconductors [Yu. S. Ponosov, V. L. Kozhevnikov, et al.; <i>FIZIKA METALLOV I METALLOVEDENIYE</i> , Vol 66 No 1, Jul 88]	33
Comprehensive Study Concerning Physics and Chemistry of $LnBa_2Cu_3O_y$ High-Temperature Superconductor Ceramics [V. P. Seminozhenko, L. A. Kotok, et al.; <i>DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСКИYE NAUKI</i> , No 6, Jun 88]	33

## Numerical Analysis, Algorithms

Idempotent Analysis as Tool in Control and Optimal Synthesis Theory. I [V. N. Kolokolitsov, V. P. Maslov; <i>FUNKTSIONALNYY ANALIZ I YEGO PRILOZHENIYA</i> , Vol 23 No 1, Jan-Feb 89]	34
Power of Open $\sigma$ -Compact Sets in Space of Noncompact Subgroups of Topological Group [A. G. Piskunov; <i>UKRAINSKIY MATEMATICHESKIY ZHURNAL</i> , Vol 40 No 6, Nov-Dec 88]	34

## Differential Equations

Class of (m,k) Methods for Solving Stiff Systems [Ye. A. Novikov, Yu. A. Shitov, et al; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, Vol 29 No 2, Feb 89]	35
Verdier Elliptical Solitons and Weierstrass Reduction Theory [Ye. D. Belokolos, V. Z. Enolskiy; FUNKTSIONALNYY ANALIZ I YEGO PRILOZHENIYA, Vol 23 No 1, Jan-Feb 89]	35
Perturbations of Self-Adjoint Operators by Singular Bilinear Forms [V. D. Koshmanenko; UKRAINSKIY MATEMATICHESKIY ZHURNAL, Vol 41 No 1, Jan 89]	35
One Class of Solutions of Quasilinear Differential System With Slowly Changing Parameters [A. V. Kostin, S. A. Shchegolev; UKRAINSKIY MATEMATICHESKIY ZHURNAL, Vol 41 No 1, Jan 89]	35
Features of Unique Solvability of Linear Boundary Value Problem for Ordinary Differential Equation [D. S. Dzhumabayev; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, Vol 29 No 1, Jan 89]	35
Asymptotics of Cauchy Problem Solution for Landau-Lifshits Equation With $t \rightarrow \infty$ [R. F. Bikbayev; TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA, Vol 77 No 2, Nov 88]	36
Wronskians of Solutions of One Class of Differential Equations With Polynomial Coefficients [V. S. Adamchik, A. D. Lizarev; UKRAINSKIY MATEMATICHESKIY ZHURNAL, Vol 40 No 6, Nov-Dec 88]	36
Inequalities of Parallelogram in Banach Spaces and Some Properties of Dual Mapping [Ya. I. Alber, A. I. Notik; UKRAINSKIY MATEMATICHESKIY ZHURNAL, Vol 40 No 6, Nov-Dec 88]	36
Action of Random Forces on Gyroscopic Systems [Yu. A. Mitropolskiy, F. U. Nosirov; UKRAINSKIY MATEMATICHESKIY ZHURNAL, Vol 40 No 5, Sep-Oct 88]	36
Green's Function for Two-Particle Coulomb Interaction in Momentum Space With Explicitly Extracted Singularities [S. A. Storozhenko, S. A. Shadchin; TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA, Vol 76 No 3, Sep 88]	36
Reparametrization of Paths in Path Integral on Finite-Dimensional Manifold [S. N. Storchak; TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA, Vol 75 No 3, Jun 88]	37

## Group Theory, Combinatorics

Stability of Solution of Integral Equation of First Kind for Limited and Compact Sets [Yu. L. Gaponenko, S. L. Logunov; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, Vol 29 No 1, Jan 89]	38
Application of Finite-Element Method to Problem of Wave Propagation Through Irregular Waveguide [A. S. Ilinskiy, A. F. Kadomtseva; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, Vol 28 No 8, Aug 88]	38

UDC 539.21

**Temperature Anomalies of Dispersion and Absorption of Sound Near Phase Transition Points at Low Temperatures**

18620129b Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 32 No 1, Jan 89 (manuscript received 8 Jan 87) pp 70-74

[Article by N. V. Shchedrina and M. I. Shchedrin, Gorkiy Institute of Water Transport Engineers]

[Abstract] There has been relatively little research on low-temperature phase transitions by acoustic methods, although the ultrasonic method has been extremely effective in investigating lattice dynamics and has been used successfully at high temperatures. In the low-temperature region no simple expressions have been derived for describing temperature anomalies. A study was therefore made of the attenuation and dispersion of sound in phase transitions with an overdamped soft mode in the low-temperature range. The temperature and frequency relations which are derived for these parameters differ from the known results applicable in the high-temperature range. The temperature anomalies are sharper. At low frequencies attenuation behaves as  $(T-T_c)^{-5/2}$  for a spectrum of critical phonons isotropic along  $k$  and as  $(T-T_c)^{-2}$  for uniaxial ferroelectric crystals. The presence of a temperature anomaly for high-frequency attenuation is also characteristic:  $(T-T_c)^{-1/2}$  and  $\ln(T-T_c)$  respectively). References 8: 6 Russian, 2 Western.

UDC 535.21

**Interaction Between Laser Radiation and Diamond Films**

18620134a Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 3, Nov 88 (manuscript received 15 Jul 87) pp 598-601

[Article by V. P. Ageyev, L. L. Buylov, V. I. Konov, A. V. Kuzmichev, S. M. Pimenov, A. M. Prokhorov, academician, V. G. Ralchenko, B. V. Spitsyn, and N. I. Chapliyev, General Physics Institute, USSR Academy of Sciences, Moscow; Physical Chemistry Institute, USSR Academy of Sciences, Moscow]

[Abstract] The possibilities of use of synthetic diamond films (DF) in such fields as microelectronics and optics makes it necessary to develop methods for local processing of their surfaces. Several methods have been proposed for solving this problem. This article describes comparative investigations of changes in the morphology of surface hypocrystalline DF induced by the radiation of XeCl and CO<sub>2</sub> lasers. Diamond films with a thickness 15-35  $\mu\text{m}$  were formed on W and Si backings measuring 6 x 8 mm from an electrically activated mixture of hydrogen and hydrocarbons passed through a reactor at a pressure 1 atm. The radiation of pulsed-periodic XeCl and CO<sub>2</sub> lasers was focused on the DF surface in spots 150 and 500  $\mu\text{m}$  in diameter. The pulse repetition rate was varied in the range 1-10 Hz. The power density in the irradiated spot attained 30 J/cm<sup>2</sup>. Laser irradiation was at different pressures. There was appreciable etching only when using UV radiation. The research demonstrated the advantages of an XeCl laser in comparison with a CO<sub>2</sub> laser in the etching of diamond films. The radiation of an excimer laser ensured an etching rate 3000 Å/pulse with a power density 8 J/cm<sup>2</sup>. It is proposed that a surface smoothing effect be used in etching for the polishing of hypocrystalline DF. With the irradiation of films by pulses of a CO<sub>2</sub> laser periodic structures with a period close to the laser wavelength will be formed. Figures 3; references 5: 2 Russian, 3 Western.



**Synthesis of Bi-Alkali Photocathodes by  
Molecular Ray Epitaxy Method**

18620120a Leningrad ZHURNAL TEKHNIЧЕСКОЙ  
FIZIKI in Russian Vol 59 No 1, Jan 89 (manuscript  
received 15 Feb 88) pp 161-165

[Article by V. V. Balanyuk, I. A. Dubovoy, V. F. Krasnov, S. L. Musher, Yu. Ye. Nesterikhin, V. E. Ryabchenko, A. M. Prokhorov, V. K. Ushakov, and M. Ya. Shchelev, Automation and Electrometry Institute, Siberian Department USSR Academy of Sciences, Novosibirsk]

[Abstract] The results of synthesis of bi-alkali (Na, K)<sub>3</sub>Sb photocathodes in a molecular ray epitaxy apparatus on an orienting sapphire backing during parallel operation of sources of Na, K and Sb fluxes are presented. A comparison of the experimental spectral curve of quantum yield with a theory taking into account the surface flexure of the bands and the energy losses of photoelectrons shows that photocathodes with an n-type conductivity are synthesized. The photocathode parameters were determined: width of forbidden band 1 eV, electron affinity 1.04 eV, surface flexure of bands 0.6 eV, mean energy losses of photoelectrons per path unit  $-7 \times 10^4$  eV/cm, concentration of donor centers  $3 \times 10^{18} \text{ cm}^{-3}$ . The success of the described experiments for the synthesis of these photocathodes makes it possible to proceed to a more detailed investigation of multi-alkali photoemission materials. This will involve a determination of the type of lattice and precise chemical composition, the relationship between molecular fluxes during epitaxy and the type of film conductivity. Figures 2; references 12: 7 Russian, 5 Western.

UDC 621.315.592.548.552.22

**Influence of Thermal Processing on Properties of  
Epitaxial Layers of GaAs Alloyed With Tin**

18620129a Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 32 No 1, Jan 89 (manuscript received 10 Dec 86)  
pp 54-59

[Article by I. A. Bobrovnikova, M. D. Vilisova, O. M. Ivleva, V. A. Moskovkin, L. P. Porokhovnichenko, and M. V. Turshatova, Siberian Physical Technical Institute imeni V. D. Kuznetsov, Tomsk State University]

[Abstract] An extensive literature is available on the thermal stability of the properties of GaAs alloyed with different admixtures. Thermal processing can result in a considerable change in the properties of crystals (type of conductivity, concentration and mobility of charge carriers, type of Raman scattering spectra, structural perfection). However, there is virtually no such information on epitaxial GaAs produced from the gas phase, although the thermal stability of epitaxial material is highly important because in modern electronic devices extensive use is made of multilayer epitaxial structures in whose fabrication each layer is subjected to annealing with the application of additional layers. The considerably different conditions for the growing of crystals and epitaxial layers suggested that their behavior may differ during thermal processing. Accordingly, a study was made of the influence exerted by annealing at temperatures 750-830° on the electrophysical, luminescent and structural characteristics of epitaxial layers of GaAs alloyed with tin at different concentrations. It was found that with a low level of alloying the layers have a high thermal stability of properties. In strongly alloyed layers in the annealing process there is a decrease in the concentration of electrons, a decrease in the lattice period and a change in the photoluminescence spectra, which is attributable to chelation and decay of the supersaturated solid solution of the alloying admixture. Figures 3; references 18: 10 Russian, 8 Western.

UDC 517.958:533.7

**Entry of Freely Expanding Gas Jet Into Circular Orifice in Transverse Barrier**

18620130c Moscow *ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI* in Russian Vol 29 No 2, Feb 89 (manuscript received 12 Jan 88) pp 277-285

[Article by A. M. Bishayev, Ye. F. Limar, S. P. Popov, and Ye. M. Shakhov, Moscow]

[Abstract] The results of numerical solution of the axisymmetric problem of the flow of a freely expanding jet of a monatomic gas onto a plane transverse barrier separating

the jet gas from a vacuum and having a circular orifice on the jet axis are given. The barrier can be infinitely thin or of a finite thickness. The case of finite thickness corresponds to an orifice of finite length (circular pipe). The objective of the study was an investigation of the flow pattern in general, including the flow in the orifice (pipe), and a determination of that fraction of the gas flow which passes through the orifice. A study was made of the influence of rarefaction of the flow, geometrical parameters and nature of the boundary conditions. The problem was solved on the basis of the Euler equations and a model kinetic equation. A regime of steady oscillations was detected at the limit of the continuous medium with moderate distances of the barrier from the nozzle section. Figures 11; references 6: 4 Russian, 2 Western.

UDC 532.516

**Computer Experiment Pertaining to Theory of Surface Wave With Finite Amplitude**

18620064a Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 302 No 4, Oct 88 (manuscript received 28 Apr 88) pp 781-785

[Article by K. I. Babenko (deceased), corresponding member, USSR Academy of Sciences, V. Yu. Petrovich, and A. I. Rakhmanov, Institute of Applied Mathematics imeni M. V. Keldysh, USSR Academy of Sciences, Moscow]

[Abstract] On the basis of earlier research done by K. I. Babenko on surface solitons and their numerical analysis, the problem of steady periodic waves with finite amplitude on the surface of an infinitely deep liquid is reduced to an equivalent system of quadratic algebraic equations in accordance with the theory of progressive waves. So as to ensure analyticity of the solution and to avoid saturation, a variant of the collocation method with equidistant interpolation and collocation nodes is selected for the numerical analysis. An even solution is sought, existence and uniqueness of such a solution being certain when  $c^2-1$  is small ( $c$ - dimensionless phase velocity). A critical parameter is  $c^2-2\gamma$  ( $\gamma$ - wave increment, a  $2\pi$ -periodic function of the potential normalized to the dimensionless phase velocity), which decreases monotonically as  $c^2$  increases and a Stokes wave appears when it becomes zero. Considering that the Jacobian of the system of algebraic equations does not degenerate, an empirically established fact, the Newton method is used for solution of the problem when  $c^2-1$  becomes large. The solution is tested for accuracy by comparing the results of computer calculations based on grids with successively larger numbers (128, 256, 512) of nodes. Tables 1; references 2: Russian.

**Magnetic Superfluidity In He-3**

18620040a Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript received 17 Oct 87) pp 100-116

[Article by E. B. Sonin, Leningrad Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences]

[Abstract] Magnetic superfluid transfer in both A and B phases of He-3 is analyzed for stability on the basis of a dynamical theory, the scale of transfer processes here being much larger than the scale of exchange processes so that the order parameter (coherence length) becomes a tensor quantity and its evolution according to this theory is reduced to rotations in the three-dimensional spin space. First, following a derivation of the applicable equations of macroscopic spin dynamics, states with dissipationless magnetic fluxes are examined from the standpoint of stability. Next are considered dissipationless precession transfer and determination of its stability limit, the latter being characterized by the critical gradient of the curl angle. Subsequent calculations for the stability limit of dissipation transfer with simultaneous curling along two fast-varying angular coordinates are made on the basis of the thermodynamic potential. Magnetic superfluid transfer is then described by theoretical interpretation of experiments involving propagation of magnetic solitons and measurements of nuclear-magnetic resonance, its stability analysis being reduced to the problem of small fluctuations about the steady state. The author thanks Yu.M. Bunkov, V.L. Golo, and I.A. Fomin for helpful discussions. Figures 2; references 28: 14 Western (1 Russian translation).

UDC 621.373.826.038.825.4

**Spectral Characteristics of Injection Laser With Intracavity Absorption Cell**

18620073a Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 18 Jun 87) pp 1730-1737

[Article by E. M. Belenov, V. L. Velichanskiy, A. S. Zibrov, G. T. Pak, T. V. Petrakova, N. V. Senkov, V. A. Sautenkov, A. V. Uskov, and A. K. Chernyshev, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] The feasibility of monochromatizing an injection laser by means of nonlinear intracavity absorption cell is evaluated on the basis of a theoretical analysis and an experiment. The narrowing of an emission line is found to be theoretically proportional to the frequency self-stabilization factor squared, assuming a simple two-level gaseous absorbing medium and ideal coupling between active and passive elements inside the cavity. The contribution of amplitude fluctuations to the width of the emission line is ignored, but natural fluctuations of the emission line are then included as "white noise" and treated according to the Shavlov-Townes relation. The experiment was performed at room temperature with a continuous-wave semiconductor laser operating at the 855 nm wavelength without external optical feedback. The adjustable-length external cavity, formed by a matching microobjective (numerical aperture 0.65, focal length 6.3 mm) and a rotatable mirror on piezoceramic sliders, contained a Cs-vapor absorption cell and also a holographic selector. Peltier cells were used for temperature regulation and smooth tuning of the natural laser modes. The tuning range could be widened so as to cover three resonances at each of the resolved spectral components. In order to identify the resonances unambiguously, it was necessary to use an auxiliary injection laser without intracavity absorption cell. One part of its radiation was mixed with that of the main laser in an avalanche photodiode and the other part was transmitted to an extracavity cell for monitoring intra-Doppler resonances. The conditions of the experiment differed appreciably from the theoretical model. The results have nevertheless established the feasibility of a highly monochromatic injection laser with a frequency self-stabilization factor of at least 10, provided an absorption with low off-resonance losses is placed inside the cavity. Figures 3; references 17: 15 Russian, 2 Western.

UDC 621.373.826.038.824

**Synchronous Pumping of Organic-Dye Jet Lasers With Sinusoidally Modulated Ar-Laser Radiation**

18620073b Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 5 Nov 87) pp 1751-1752

[Article by G. I. Ray, B. P. Ustinov, and G. V. Sharonov, Scientific Research Institute of Problems in Physics imeni A. N. Sechenko, Minsk]

[Abstract] Synchronous pumping of organic-dye jet lasers by a simple method is described, a continuous-wave ionic Ar-laser with an external acoustooptic standing-wave modulator being used for this purpose. The

pumping radiation is sinusoidally modulated at the frequency of intermodal beats in the dye laser. The method was tested on a "Coherent Radiation" CR-599 rhodamine-6G laser (3 mmol/l rhodamine-6G in ethylene glycol, 570 nm wavelength, 150 mW emission threshold) with an ILA-120-1 Ar-laser operating at 457.9-514.5 nm wavelengths and delivering a maximum integral average pumping power of 3 W. As modulator was used an M-202 cell with the active faces cut at the Brewster angle. A high-frequency signal was transmitted to this modulator by a frequency synthesizer (49.9568 MHz) through a power amplifier, with a loss modulation factor of 35 pct. The optical length of the cavity for the dye laser matched the 49.9568 MHz pump modulation frequency. Owing to the long duration of pump pulses (350 ps at half-amplitude level) and the long period of the modulating sine wave (5 ns) relative to the 100 ps pulse duration in the case of an AR-laser with active mode locking, the expected pulse compression in the dye laser did not occur over a wide range of stable mode locking. Figures 2; references 2: Russian.

UDC 621.373.826.038.825.2

**Performance of Gd-Sc-Al: Cr, Nd Garnet Laser**

18620073c Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 24 Dec 87) pp 1760-1761

[Article by A. A. Danilov, A. L. Denisov, Ye. V. Zharikov, A. I. Zagumenny, G. B. Lutts, M. Yu. Nikol'skiy, V. B. Tsvetkov, and I. A. Shcherbakov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] An active medium with a high thermal conductivity of 0.11 W/cm.K has been developed for a solid state laser, namely a Gd-Sc-Al garnet doubly doped with  $2 \cdot 10^{20} \text{ cm}^{-3}$  Cr and  $1 \cdot 10^{20} \text{ cm}^{-3}$  Nd. The laser operates at the 1.060 mm wavelength. It was tested in a cavity formed by a spherical opaque mirror and a plane exit mirror, with optical pumping by an INP-5/60A Xe-lamp placed inside an Ag-coated elliptical quartz envelope and emitting flashes of 1.5 ms duration. The laser was tested with three different exit mirrors, the reflection coefficient being 0.9, 0.26, 0.18 respectively, the 0.18 mirror yielding the best laser performance in terms of 3.4 pct absolute efficiency and 4.4 differential efficiency in the free-running monopulse mode. For a determination of the laser beam divergence, its dependence on the average optical pump power and on the pump pulse repetition rate, measurements were made in a cavity formed by two plane dielectric mirrors with the reflection coefficient 1.0 and 0.18 respectively. At higher power levels the divergence was much smaller than that of the radiation beam emitted by a Y-Sc-Ga:Cr,Nd garnet laser. Also the

detrimental thermooptic effect was found to be appreciably weaker in a Gd-Sc-Al garnet than in a Y-Sc-Ga garnet. Figures 2; references 7: Russian.

UDC 621.373.826

**New Possibility of Diatomic Dimer Lasers With Solar Pumping**

18620073d Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 12 Jun 87) pp 1791-1796

[Article by A. L. Golger, I. I. Klimovskiy, and A. V. Morozov, Institute of High Temperatures, USSR Academy of Sciences, Moscow]

[Abstract] A new possibility of a diatomic dimer photodissociation laser with solar pumping is established theoretically, as active medium being proposed a vapor of either homonuclear B<sub>2</sub> or heteronuclear BC metal molecules with a noble gas as buffer medium. The main advantages of such active media, a broad variety of them being available, are stability of their composition during pumping and negligible overheating during radiation emission. The necessary concentration of solar pumping energy is relatively low, moreover, when the equilibrium between B atom concentration and B<sub>2</sub> or BC molecule concentration shifts toward formation of dimers. An analysis based on the equations of kinetics for the population of atomic-molecular levels has yielded the conditions for inversion at the laser transition and for a high-efficiency laser, transverse pumping being optimum. The optimum width of the active medium for absorption of all solar pumping energy and the output power of such a laser are determined on this basis. Numerical estimates indicate that a laser efficiency of 3 pct is attainable with a solar-energy concentration factor less than 100, for which a paraboloido-cylindrical heli-concentrator is adequate. Figures 3; references 21: 12 Russian, 9 Western (1 in Russian translation).

UDC 621.373.826

**Adaptive Methods of Light-Beam Shaping Under Conditions of Speckle-Modulation of Scattered Field**

18620073e Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 5 May 87) pp 1925-1930

[Article by M. A. Vorontsov, I. A. Kudryashov, and V. I. Shmalgauzen, Moscow State University imeni M. V. Lomonosov]

[Abstract] An experimental study of a multichannel system for adaptive focusing of a light beam in an optically nonhomogeneous medium onto a large rough reflector surface was made, speckle-modulation of the field scattered by such a surface causing photocurrent fluctuations in the photodetector. The optical part of the apparatus consisted of a laser, a flexible-mirror wavefront corrector

and an identical flexible-mirror wavefront distorter, a medium simulator, a rotating reflector with rough surface, a photomultiplier behind a diaphragm, a television camera, a multielectrode modal corrector, also six lenses and two beam-splitter plates. The 15-channel feedback loop from the photomultiplier and from the camera to the wavefront corrector included a spectrum analyzer, an analog-to-digital converter in a CAMAC crate, and Elektronika-80 microcomputer with a graph plotter, a corrector control, and an image-to-code converter for computer input with a telemonitor. In the experiment was determined the dependence of the photocurrent fluctuations and of the integral beam width on the voltage at the center drive of the modal corrector, also the dependence of the statistical focusing criterion during scanning of the reflector surface on that voltage and on the integral beam width. The results indicate the feasibility of compensating dynamic wavefront distortions by keeping sufficiently many high-speed control channels active. Figures 5; references 9: 6 Russian, 3 Western (1 in Russian translation).

UDC 621.373.826

**Laser With Stimulated-Brillouin-Scattering Mirror Switchable by Intrinsic Starter Radiation**

18620073f Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 9, Sep 88 (manuscript received 3 Jun 87) pp 1905-1908

[Article by P. P. Pashinin and Ye. I. Shklovskiy, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] A simple method of efficiently producing a diffraction-limited laser beam completely covering the aperture of the active element of a solid-state laser with Q-switching is proposed, namely use of a switchable stimulated-Brillouin-scattering mirror outside the cavity. The method was tested on a YAlO<sub>3</sub>:Nd active element 6.3 mm in diameter and on a Gd-Sc-Ga:Cr,Nd active element 3 mm in diameter, each capable of ensuring a gain as high as 30 in a single pass, inside a cavity between two plane mirrors. A 20 cm long cell with TiCl<sub>4</sub> served as the extra cavity s-B-s mirror, switchable by intrinsic starter radiation focused on it through a lens. The starter radiation was clamped to the geometrical axis of the active element by a plane-parallel LiF crystal with F<sub>2</sub><sup>-</sup> color centers acting as filter-diaphragm. These lasers were tested in both monopulse and periodic-pulse operation, the pulse repetition rate in the latter case being increased till single-mode emission was cut off. Up to 80 pct of the laser energy was contained within the Gaussian core of the beam, the total emission energy depending on the reflection coefficient of each cavity-forming mirror and on the initial transmission coefficient of the filter-diaphragm. The emission efficiency depends also on the reflection coefficient of the s-B-s mirror, numerical estimates indicating that its reflection coefficient is rather high. The authors thank S. B. Mirov for supplying the LiF:F<sub>2</sub><sup>-</sup> shutter, I. A. Shcherbakov for supplying the Gd-Sc-Ga:Cr,Nd active element, and R. V. Serov for helpful discussions. Figures 2; references 7: 5 Russian, 2 Western.

UDC 621.373.826

**Anomalous Formation of Defects in  $V_2O_3$  During Laser Treatment**

18620074 Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 9, Sep 88 (manuscript received 17 May 88) pp 150-151

[Article by A. V. Manukhin, V. A. Stepanov, and O. A. Plaksin, Moscow Institute of Steel and Alloys]

[Abstract] Changes in the optical properties of  $V_2O_3$  single crystals during laser treatment, detected in experiments with a  $CO_2$ -laser emitting a pulse of 4 ms duration every 45 ms with a power density of 126 W/cm<sup>2</sup> for treatment of  $V_2O_3$  specimens under vacuum at a temperature averaging 180 K per cycle, could not possibly be explained in terms of a thermal mechanism alone. Calculations based on parameters of the experiments and accounting for the temperature relaxation process yield an estimated 250 K peak temperature. Meanwhile, examination of  $V_2O_3$  single crystals under an electron microscope revealed formation of oxygen vacancies and of superstructures with appearance of a  $V_4O_9$  phase during annealing under vacuum at temperatures above 400 K but not at temperatures below 400 K. Therefore, the breeding of oxygen vacancies during laser treatment is anomalous. The results of subsequent experiments, 0.050 mm thick wafers of  $V_2O_3$  single crystals being treated with a  $CO_2$ -laser (10,600 nm) and with a Co-laser (5,000 nm) in the continuous-wave mode in an argon atmosphere, indicate that this anomaly is attributable to resonant absorption of infrared radiation (approximately 1.5 times more intense within the 1.2-0.9 eV band during treatment with the  $CO_2$ -laser than during treatment with the  $CO_2$ -laser) and subsequent excitation of lattice oxygen atoms into vibrations resulting in oxygen vacancies. References 5: 2 Russian, 3 Western.

UDC 621.373:535(206.1)

**Generation of Solid-State Lasers With Self-Pumping Reversed Wave Front Cavity**

18620103a Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 3, Sep 88 (manuscript received 27 Apr 88) pp 506- 507

[Article by V. A. Berenberg, A. Ye. Vasilyev, I. V. Mochalov, G. T. Petrovskiy, M. A. Kharchenko, and V. V. Shuvalov]

[Abstract] Lasers with self-pumping reversed wave front cavity mirrors (SPRWFM) are promising for the compensation of intracavity aberrations. SPRWFM in an active medium are of particular interest because they make it possible to dispense with the introduction of additional nonlinear elements within the cavity. Such a scheme has already been embodied in  $CO_2$  lasers and lasers operating on copper vapors. In this article it is shown that such a mechanism can also be used in solid state lasers with a

sufficiently great amplification factor, such as in media containing neodymium. The generation obtained for the first time in a self-pumping reversed wave front cavity with two SPRWFM affords prospects for the use of optically inhomogeneous active elements in a solid state laser without a substantial worsening of the spatial-energy characteristics of the output radiation. A diagram shows instrument structure and the text describes the operating principle. YAG-Nd<sup>3+</sup> active elements were used in the experiments. Qualitatively similar results were obtained for all active media. The results show that the saturation of amplification by an active medium is a promising nonlinearity mechanism for the practical realization of generator schemes with SPRWFM because the sections of the amplification and nonlinear reflection processes are self-consistent. Figure 1; references 5: 4 Russian, 1 Western.

UDC 621.373:535

**Shortening of Laser Pulse by Nonlinearly Absorbing Media**

18620103b Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 3, Sep 88 (manuscript received 6 Jul 87) pp 698- 701

[Article by E. V. Bezlenko, M. V. Bogdanova, and V. M. Mizin]

[Abstract] The possibility of obtaining short laser pulses from longer pulses is discussed. Recently a study was published along these lines by T. Varghese (APPL. PHYS. LETT., Vol 41, p 684, 1982). An effort has been made at experimental checking of this possibility at a wavelength of 1.06  $\mu$ m, for which there is a great number of nonlinearly absorbing media with substantially differing characteristics. The experimental apparatus is illustrated and described. This apparatus made it possible to analyze a shortening scheme with allowance for different experimental conditions and to compare the computed and experimental results. The limiting characteristics of the pulse shaper were determined; these are consistent with the computed data. The described experiment, confirmed by computations, provides evidence of a possibility for optimization of the shaper: with appropriate choice of the parameters of the absorbing medium it is possible to achieve an effective shortening of the pulse with an entirely reasonable (by a factor of 20-30) attenuation of the latter. Figures 3: 4 Russian, 6 Western.

UDC 621.373:535-3

**UV Generation During Pumping of He-Cd Mixture by Electron Beam**

18620103c Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 3, Sep 88 (manuscript received 14 Jul 87, after revision 19 Feb 88) pp 744-747

[Article by S. P. Bugayev, F. G. Goryunov, D. Yu. Nagornyy, V. S. Skakun, V. F. Tarasenko, and A. V. Fedenev]

[Abstract] A He-Cd laser is highly desirable because it has a low generation threshold, relatively low working

temperature for lasers based on metallic vapors and generation is possible in the visible, UV and IR spectral regions. An increase in pressure of the working mixture usually makes it possible to improve the energy characteristics of the laser. However, with an increase in helium pressure no generation threshold was attained at 325 nm, despite use of a number of pumping methods. This article reports on the achievement of generation in the UV region at 325 nm and at about 361 nm with the pumping of a He-Cd mixture at atmospheric pressure by a nanosecond electron beam. Excitation was by an electron beam from a small X-ray machine and using a longitudinal pumping scheme with electron beam rotation by a longitudinal magnetic field. The central part of the laser chamber was heated to 600° and the length of the heated region was 40 cm. The diameter of the electron beam injected into the active region was about 1.2 cm and the maximal beam current density was 100 A/cm<sup>2</sup>. With pressure variation of the buffer gas helium and working temperature generation was observed at both 325 nm and about 361 nm. The reasons for this success are discussed. Figure 2; references 10: 7 Russian, 3 Western.

UDC 535.34+621.375.535

#### **Increasing Sensitivity of High-Resolution Intracavity Spectrometers by Use of Continuously Tunable Lasers**

18620039a Minsk *ZHURNAL PRIKLADNOY SPEKTROSKOPII* in Russian Vol 49 No 2, Aug 88 (manuscript received 18 Feb 87) pp 206-209

[Article by S. F. Lukyachenko and A. M. Solodov]

[Abstract] The feasibility of increasing the sensitivity of high-resolution intracavity spectrometers for analysis of liquids and gases by use of continuously tunable lasers has been established theoretically and experimentally, such a laser reconciling the contradictory requirements of an emission line much wider than those of the analyzed substance of high sensitivity and of a narrow emission line for high resolution. A pulsed glass: Nd<sup>3+</sup>-laser with a narrow but fast tunable emission line, a single-mode ring laser with inner cell and multipass outer cell containing ammonia under appropriately

matched pressures, was found to be satisfactory. The experiment with such a laser revealed that the tuning rate must not exceed a certain critical one, lest the increase of the absorption coefficient for the analyzed spectral line at the center of that line be accompanied by an asymmetric dip in the absorption spectrum or by emission cutoffs with transition from one emission mode to another within that absorption dip band. This occurred even with an interference plate inside the cavity as simulator of an analyzed spectral line. Figures 2; references 4: 3 Russian, 1 Western.

#### **Use of XeCl and KrF Excimer Lasers for Diagnostic Flame Analysis by Method of Spontaneous-Raman-Scattering Spectroscopy**

18620033a Novosibirsk *FIZIKA GORENIYA I VZRYVA* in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 1 Jul 87) pp 54-58

[Article by A. N. Malov and S. Yu. Fedorov, Novosibirsk]

[Abstract] An apparatus of diagnostic flame analysis with high time resolution has been designed and built which includes a XeCl or KrF ultraviolet excimer laser and a spontaneous-Raman-scattering pulse spectrometer. The laser beam passes through a focusing lens to a photoelectric colorimeter feeding signals to a memory oscillograph, also through two projecting lenses backed by a light absorber to a DMR-4 dual monochromator preceded by a diaphragm and followed by a photomultiplier feeding signals through a correlated sampler to a recording device as well as to a universal voltmeter. This spectrometer operates either with the laser operating in the periodically-pulsed mode and the monochromator sweeping the spectrum or with the laser operating in the monopulse mode, with the signal amplitude normalized to the laser radiation energy, and with the monochromator tuned to a specific spectral band. With this apparatus were experimentally recorded spectra of spontaneous Raman scattering in normal air, in a hydrogen jet, and in a diffuse air-hydrogen flame for quantitative determination of N, O, H, mainly but also H<sub>2</sub>O and other components. The authors thank Yu. I. Krasnik for assisting in design of the correlated sampler. Figures 3; references 6: 3 Russian, 3 Western (1 in Russian translation).

**Microscopic Theory of Spectrum of Single-Particle Excitations of Normal Fermi Systems**

18620117a Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 1, Jan 89 (manuscript received 26 Jan 88)  
pp 52-58

[Article by V. A. Khodel and V. R. Shaginyan, Leningrad Nuclear Physics Institute, USSR Academy of Sciences]

[Abstract] Interest has recently increased in heated nuclear matter, to a great degree attributable to publication of data from various experiments on the collision of heavy ions. However, for the time being there is no well-developed theory for describing the properties of a nuclear medium. Accordingly, a new approach is proposed for computing the parameters of nuclear matter, in particular effective mass, single-particle spectrum and free energy. Specifically, a microscopic theory of single-particle excitations in normal Fermi systems is proposed within the framework of the density functional method. A system of equations is derived which makes it possible to compute the effective mass of a quasiparticle by using the interaction between particles in a vacuum as a point of departure. A system of equations is also proposed for computing the thermodynamic functions of heated nuclear matter (these equations do not contain any parameters). References 15: 7 Russian, 8 Western.

**Possible Resolution of 'Spin Crisis' in Parton Model**

18620117b Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 1, Jan 89 (manuscript received 21 Jul 88)  
pp 214-222

[Article by M. Anselmino, B. L. Ioffe and E. Leader, Institute of Theoretical and Experimental Physics, State Committee for Use of Atomic Energy, Birkbeck College, London University]

[Abstract] Recent experiments under the EMC [European Muon Collaboration] Program on strongly inelastic scattering of longitudinally polarized muons on longitudinally polarized protons have become a source of both excitement and confusion because these data lead to the surprising conclusion, contradicting intuition, that the total projection of spin of all quarks and antiquarks onto the spin direction of a polarized proton is close to zero. Serious doubts prevail as to whether it is true that the total proton spin consists of the spins of its Parton components (the so-called "spin crisis"). Various attempts have been made to resolve this contradiction, but none seem satisfactory. In this article the different approaches to this problem are critically discussed. Emphasis is on the important role played by the Gerasimov-Drell-Hearn sum rule in investigation of this problem. It was found that the total spin of quarks is evidently not so small as suggested by an ordinary analysis of experiments of the EMC group and that the theoretically predicted value of the projection of proton

spin carried by u- and d-quarks can be brought into consistency with experimental data within the limits of experimental errors. Figures 2; references 22: 2 Russian, 20 Western.

**Theory of Photon Interferometry for Quark-Gluon Plasma**

18620117c Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 1, Jan 89 (manuscript received 28 Mar 88)  
pp 238-248

[Article by A. N. Makhlin, Kiev Polytechnic Institute]

[Abstract] The generation of high-energy photons and dileptons in nuclear collisions is a necessary but by no means adequate indicator of the existence of quark-gluon plasma. Both can be generated in hard processes or in decays of mesons and meson resonances. The only reliable indicator of the formation of quark-gluon plasma may be a determination that in a nuclear reaction there is actually a spatial-temporal region filled with heated, at rest or expanding matter in a state of local thermodynamic equilibrium which is also a source of photons and dileptons. Recent research with pion interferometry for the hydrodynamic stage of multiple processes indicated that it can serve as an extremely sensitive tool for detecting internal hydrodynamic motion in nuclear matter, but only in the last, predecay stage of its evolution. A dilepton interferometry scheme for quark-gluon plasma has also been proposed, but its effectiveness at present is minimal. However, the explicit dependence of the photon correlator on the parameters determining the entire course of hydrodynamic evolution makes it possible to hope that photon interferometry can broaden the framework of analysis of the hydrodynamic mode of quark-gluon plasma. This is demonstrated by computations of single- and two-particle inclusive spectra of photons emitted by hot optically transparent quark-gluon plasma. It is shown that photon interferometry is effective for detecting both the plasma itself and the hydrodynamic regime of its evolution. References 11: 9 Russian, 2 Western.

UDC 538.945:530.182

**Thermal Autooscillations and Autowaves in Superconductor Connected to External Circuit**

18620108b Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 58 No 11, Nov 88 (manuscript received 10 Sep 87) pp 2219-2227

[Article by Yu. M. Lvovskiy, Geotechnical Mechanics Institute, Ukrainian Academy of Sciences, Dnepropetrovsk]

[Abstract] Nonlinear thermal processes in a superconductor connected to an external electrical circuit are examined. With allowance for the dynamics of the



circuit these nonlinear thermal processes in the superconductor acquire qualitatively new properties characteristic for autowave media with restoration. This indicates the feasibility of analysis of problems in thermal stabilization of superconductors jointly with modeling of an external circuit. It was found that in the working region of parameters in a superconductor there are hard resistive-normal autooscillations so that, depending on the magnitude of the perturbation, the system either returns to a superconducting state or passes into an autooscillatory mode. With a smooth change in autooscillation parameters a jump of finite amplitude arises which is dangerous for operation of the superconducting system. The interaction of several mechanisms gives rise to a diversity of types of hard autooscillations, which corresponds to different positionings of stable and unstable cycles. It is postulated that the seven regions of different behavior determined by these mechanisms are common for certain physical autooscillatory systems. A diagram is given showing the complete picture of possible modes, making it possible to trace the change in modes with a change in parameters, and also to estimate the size of the inhomogeneities (conductor defects, sectors of worsened heat exchange, etc.) on which autooscillations may develop. The behavior of a nonmonotonic thermal wave in an extended superconductor, undergoing a number of successive stages in its development, is described. Figures 5; references 18: 11 Russian, 7 Western.

#### **Anomalies in Radiation Pattern of Channeled Electrons**

18620071a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 7, 10 Oct 88 (manuscript  
received 29 Aug 88) pp 364-366

[Article by A. O. Aganyants, Yu. A. Vartanov, V. B. Karibyan, and V. Ya. Yaralov]

[Abstract] An experimental study involving the inner electron beam and a diamond single crystal as target in the Yerevan synchrotron has revealed an anomaly contradicting currently prevalent theoretical concepts about the angular distribution of gamma quanta leaving such a crystal upon entrance of high-energy electrons. The divergence of the electron beam was of the order of 0.05 mrad and thus smaller than the 10 mrad Lindhard critical channeling angle for 4.4 GeV electrons impinging on the (011) plane of such a crystal. Measurements were made with a dual magnetic spectrometer and with a narrow movable target for scanning the profile of the emitted gamma beam in only one of its horizontal projections at a time. The results revealed an azimuthal asymmetry at the 3 GeV energy level and thus within the noncoherent part of the gamma radiation spectrum, while theoretically emission of gamma radiation should become very directional within the low-energy and thus coherent part of the spectrum only. The anomaly is possibly attributable to linear polarization of the gamma beam. Figures 3; tables 1; references 7: 6 Russian, 1 Western.

#### **Multiphonon States of One-Dimensional Chain With Anharmonicity**

18620040b Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript  
received 23 Feb 88) pp 283-296

[Article by A. N. Orayevskiy and M. Yu. Sudakov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] Multiphonon states in a one-dimensional chain of interacting molecules are analyzed, taking into account anharmonicity of intramolecular vibrations and attendant formation of soliton waves of vibrational excitations. As the physical model is selected a one-dimensional lattice containing a non-displaceable molecule with a vibrational internal degree of freedom in each node. The energy level diagram and the Hamiltonian are constructed, considering first the two simpler extreme cases of free oscillators (no quantum transfer Q from one molecule to another) and of harmonic oscillators (zero energy G associated with anharmonicity of molecular vibrational quantum). The spectrum of the Hamiltonian and the wave functions for the corresponding steady-state Schroedinger equation are constructed next. The energy band structure and the dispersion laws for quasiparticles in the lattice model are then compared with their analogs in the continuum model, whereupon solitons and multiphonon complexes are compared with the difference analog of the nonlinear Schroedinger equation integrable by the method of the inverse scattering problems as criterion. In conclusion, the correspondence principle is established for soliton theory and the classical soliton solution to the classical nonlinear Schroedinger equation is found to correctly describe anharmonic solitons in terms of quantum dynamics of vibrational excitations in the absence of quantum-mechanical dispersion only. The authors thank V. M. Agranovich, V. Rupasov, and Ye. Ogiyevetskiy for interest and important comments. Figures 5; references 14: 7 Russian, 7 Western (2 in Russian translation).

#### **Stochastic Aggregation of Particles Upon Their Pulsed Excitation and Subsequent Recombination in Fractal Systems and in Homogeneous Systems**

18620040c Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript  
received 23 Dec 87) pp 199-206

[Article by I. M. Sokolov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] Excitation of particles by a radiation pulse and their subsequent recombination are considered, in the mesoscopic approximation, of interest being the

kinetics of their attendant aggregation and the asymptotic behavior of their concentration during the intermediate period of the order of the pulse duration as well as during the remaining period after turn-off. The distribution of particles is first treated generally in systems of arbitrary spatial and spectral dimensionality. Independent generation of particles and then the more important case of their pairwise generation are considered. Analysis of and calculations for both spatially and spectrally three-dimensional fractal systems and one-dimensional ones are compared with analysis of and calculations for homogeneous systems of corresponding dimensionalities. The author thanks L. V. Keldysh and A. V. Kondrachuk for helpful discussions. Figures 1; references 17: 7 Russian, 10 Western.

UDC 539.18

### Acoustic Muon-Spin Resonance in Ferromagnetic Materials

18620041a Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 302 No 1, Sep 88 (manuscript received 12 Jun 87) pp 80-82

[Article by Yu. M. Belousov and V. P. Smilga, Moscow Institute of Engineering Physics]

[Abstract] Spin-phonon interaction with an acoustic wave at resonance in a ferromagnetic substance in which muons dwell without diffusing is considered, and a free positive muon (metals) in a magnetic field is known to exist in two intrinsic states when a Muatom (dielectrics, semiconductor) forms. The local magnetic field on a muon in the presence of an acoustic waves is calculated, ignoring depolarization, with the magnetic field generated by an acoustic wave depending on the material. The resulting muASR-effect is found to be a convenient tool for studying ferromagnetic materials by the muon method, there being no special constraints on the acoustic generator power such as the saturation of the spin system which limits it in the case of acoustic nuclear-magnetic resonance. Article was presented by Academician S. T. Belyayev on 2 June 1987. References 5: 4 Russian, 1 Western.

UDC 537.31:538.913

### Indirect Electron-Electron Interaction Through Solitons in Anharmonic Lattice

18420041b Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 302 No 1, Sep 88 (manuscript received 28 May 87) pp 85-88

[Article by Yu. A. Izyumov and V. M. Laptev, Institute of Metal Physics, Ural Department, USSR Academy of Sciences, Sverdlovsk]

[Abstract] Electron-electron interaction in a strongly anharmonic lattice is analyzed, with the main difficulty stemming from the quantum nature of electrons and the classical nature of a lattice with known soliton solutions. Following quasi-classical quantization by replacement of

Poisson brackets with commutators, then assuming a rarefied soliton gas in the continuum approximation and using the quasi-one-dimensional model with two potential wells, the part of that interaction occurring through linear and nonlinear modes is calculated according to perturbation theory of the second order with respect to electron-lattice coupling. The results show phonon contributions to this interaction with the contributions corresponding to virtual phonon absorption and emission processes as well the contribution corresponding to virtual interaction with bond phonons. The authors thank Yu. V. Kopayev, V. F. Yelesin, and N. M. Plakid for discussions. Article was presented by Academician S. V. Vonsovskiy on 25 May 1987. References 2: Western.

### Cold Compact and Cold Deformed Spontaneous Fission of $^{252}\text{Cf}$

18620066a Moscow YADERNAYA FIZIKA in Russian Vol 48 No 3 (9), Sep 88 (manuscript received 16 Nov 87) pp 655-660

[Article by I. D. Alkhazov, A. V. Kuznetsov, S. S. Kovalenko, B. F. Petrov, and V. I. Shapkov, Radium Institute imeni V. G. Khlopin]

[Abstract] Prompt neutrons emitted by paired fragments upon spontaneous fission of  $^{252}\text{Cf}$  were recorded simultaneously with two liquid scintillation counters containing Gd, the multiplicity of these neutrons providing direct information about both the fragment excitation energy and the fragment deformation. On the basis of these data has been identified a compact cold fission structure with zero neutron multiplicity and with even-odd charge effects, the compact shell becoming deformed as the neutron multiplicity increases along with the fragment excitation energy and with the fragment mass. Quantitative analysis of the fragment mass dependence of the average number of emitted prompt neutrons, with a strong suppression of the peak at the mass number 132 corresponding to a double-magic spherical shell with 50 protons and 82 neutrons, indicates that cold deformed fission is attributable to deformation of one of the fragments rather than to deformation of the entire system as a whole and, therefore, involves quantum efforts at the separation point. The results reveal, furthermore, that cold deformed fission occurs not only when the excitation energy is extremely high but also when it is near the average of a maximally asymmetric distribution between fragments. Figures 4; references 11: 2 Russian, 9 Western.

### Coefficient of Muon Adhesion to Helium

18620066b Moscow YADERNAYA FIZIKA in Russian Vol 48 No 3 (9), Sep 88 (manuscript received 12 Aug 86) pp 679-681

[Article by Ye. M. Gandyl and A. L. Zubarev, Tashkent State University]

[Abstract] The coefficient to muon adhesion to helium, an important parameter of muon catalysis  $\mu^-$  plus d plus t yielding  $\mu^-$  plus  $^4\text{He}$  plus n plus 17.6 MeV, is

calculated on the basis of the probabilities that helium mesoatoms forming in this process are in states of a discrete spectrum or a continuous spectrum respectively. The obtained value of this coefficient is shown to depend largely on construction of the wave function for solution of the Fadeyev-Hahn equations by the variational method, which involves some indeterminacy, in the approximation of sudden perturbations. The various values are compared with experimental determinations and with values given by other authors. The authors thank V. B. Belyayev and Yu. V. Petrov for interest. Tables 1; references 21: 6 Russian, 15 Western.

**Search for Decay of Neutral Rho Meson Into Positive Pion Plus Negative Pion Plus Neutral Pion**

18620066c Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 3 (9), Sep 88 (manuscript received 25 Dec 87)  
pp 753-756

[Article by I. B. Vasserman, V. B. Golubev, S. I. Dolinskiy, V. P. Druzhinin, M. S. Dubrovin, V. N. Ivanchenko, I. A. Koop, Ye. V. Pakhtusova, A. N. Peryshkin, S. I. Serednyakov, V. A. Sidorov, and Yu. M. Shatunov, Institute of Nuclear Research, USSR Academy of Sciences]

[Abstract] In search for the theoretically possible but not yet experimentally discovered decays of a neutral rho meson into a positive pion plus a negative pion plus a neutral pion, electromagnetic mixing of a neutral rho meson and an omega meson as the intermediate stage of positron plus electron decay into these three pions was monitored in an experiment with the Neutral detector on the VEPP-2M electron-positron accumulator. Tests were performed with 660 MeV and 950 MeV total energy of both electron and positron beams, the main difficulty in recording the decay of a neutral rho meson being its manifestation as a faint interference effect on the slopes of narrow omega-resonance. However, the upper bound for the magnitude of its direct decay into the three pions without passage through the intermediate omega-state could be established by analysis of the data and was found to correspond to an upper bound of  $4 \cdot 10^{-5}$  for the branching ratio. The authors thank N. N. Achasov, G. N. Chestakov and A. I. Vaynshteyn for discussions. Figures 1; references 16: 6 Russian, 10 Western.

**Compatibility of Small Neutrino Mass and Large Neutrino Magnetic Moment**

18620066d Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 3 (9), Sep 88 (manuscript received 7 Dec 87)  
pp 804-810

[Article by M. B. Voloshin, Institute of Theoretical and Experimental Physics, State-Controlled Institute of Atomic Energy]

[Abstract] The premise that a neutrino has a very large magnetic moment reaching  $10^{-11}$ - $10^{-10}$  Bohr magnetons and an extremely small mass not exceeding 30 eV is analyzed for compatibility of such magnitudes, both being

assumed in order to account for loop effects and explain possible modulation of a solar neutrino flux in time. The question whether a ratio of electron charge times neutrino mass to neutrino magnetic moment correspondingly of the order of only a  $\text{GeV}^2$  is physically natural or not is considered, such a ratio being technically attainable inasmuch as a neutrino mass can be freely assumed to be arbitrarily small while a large neutrino magnetic moment can be expected in  $\text{SU}(2)_L \times \text{SU}(2)_R$  schemes and an even larger one in models with charged scalar particles. Such a ratio would be a consequence of  $\text{SU}(2)$  neutrino-antineutrino symmetry, were it not that a neutrino magnetic moment is allowed but a neutrino mass is forbidden in the exact  $\text{SU}(2)$  symmetry. The model with  $\text{SU}(4)$  symmetry in the lepton sector is considered, therefore here charged scalar particles of the  $\text{SU}(4)$  sextet yielding a neutrino magnetic moment and electroweak radiative corrections yielding a neutrino mass. Charged scalar particles of only less than 100 GeV magnitude are required for explaining a neutrino mass smaller than 30 eV and such particles are quite likely to be found in TRISTAN, SLC, LEP electron-positron colliders. Figures 3; references 15: 5 Russian, 10 Western.

**Exactly Solvable Model of Field Theory With Tachyons**

18620066e Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 3 (9), Sep 88 (manuscript received 4 Jan 88)  
pp 886-889

[Article by I. V. Barashenkov and B. S. Getmanov, Joint Institute of Nuclear Research and V. Ye. Kovtun, Khartov State University]

[Abstract] The two-dimensional  $0(1,1)$  sine-Gordon model of a scalar field is examined, this model being related to the two-dimensional  $0(2)$  sine-Gordon model of such a field through which relativistic springs dynamically interact and the two respective Lagrangians being similar in form. Unlike that other one, however, this also integrable model has exact soliton solutions describing inelastic interaction of two solitons: a bradyon slower than light and a tachyon faster than light. These solutions are shown to admit nontrivial degeneracy. An evaluation of the motion integrals according to the classical field theory and thus covering the entire time axis from minus to plus infinity reveals that relativization occurs automatically and that the energy of the tachyon remains non-negative in any reference system. The authors thank Professor E. Rekami and Ya. A. Smorodinskiy for supportive comments. Figures 1; references 12: 7 Russian, 5 Western.

UDC 523.6+524.5-4

**Reconstruction of Energy Spectra of Neutrons Generated During Solar Flares on Basis of Electrons Produced in Decay of Those Neutrons**

18620060 Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA in Russian  
No 4 (143), Jul-Aug 88 (manuscript received 27 Oct 87)  
pp 60-66

[Article by Ye. V. Kolomeyets, V. N. Sevostyanov, and Ye. A. Chebakova, Kazakh State University imeni S. M. Kirov, Alma-Ata]

[Abstract] Calculating the energy spectrum and the time profile of electrons produced in decay of low-energy neutrons is proposed for reconstructing the energy spectrum of neutrons with less than 10 MeV energy generated during solar flares, neither a neutron detector on a satellite and a neutron monitor on Earth nor data on protons produced in decay of flare neutrons being adequate for this purpose while, on the other hand, even lowest-energy neutrons decay near the sun as far as the orbit of Earth and yield 0.3 MeV electrons in the process. These electrons fall on lines of force of the interplanetary magnetic field, its lines of force being Archimedean spirals, and then move along them while being scattered by magnetic inhomogeneities. Calculations take into account the velocity of solar wind and the sidereal velocity of sun's rotation. The results of such calculations using data from the 3 June 1982 solar flare indicate that reconstruction of the energy spectrum of the low-energy flare neutrons requires probing solar flares which occur west of the 50 deg solar longitude, those which occur more to the east yielding adequate data for reconstructing the energy spectrum of the high-energy flare neutrons. Figures 4; references 6: 1 Russian, 5 Western.

**Instability and Collapse of Solitons in Media With Defocusing Nonlinearity**

18620030b Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 8, Aug 88 (manuscript  
received 4 Feb 88) pp 119-129

[Article by Ye. A. Kuznetsov and S. K. Turitsyn, Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences]

[Abstract] The behavior of solitons is analyzed according to the nonlinear Schroedinger equation with repulsion, this equation describing propagation of an electromagnetic wave packet through a medium with a defocusing nonlinearity and also simulating gas dynamics with dispersion. First is considered the linear problem of soliton stability under small multidimensional perturbations, solution of which yields the spectrum of bound states with an edge where small oscillations vanish. The instability increment at this long-wave edge is then calculated by the method of perturbation theory. The solution to the problem is shown to be stable near a domain wall, even though a free domain wall is inherently unstable, when the additional constraint of zero oscillation frequency is stipulated at the wall. A one-dimensional soliton is then shown to be unstable under sufficiently large transverse perturbation. This instability, which leads to collapse following its nonlinear stage, is analogous to Kadomtsev-Petviashvili instability of acoustic solitons in weakly dispersive media. The authors thank Ye. G. Shapiro for calculating the instability spectrum on a computer. Figures 1; references 23: 16 Russian, 7 Western.

**Effect of Gravitation on Diffraction of Neutrons by Bent Single Crystal of Quartz**

18620030c Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 8, Aug 88 (manuscript  
received 28 Jan 88) pp 371-383

[Article by V. L. Alekseyev, Ye. G. Lapin, Ye. K. Leushkin, V. L. Rumyantsev, O. I. Sumbayev, and V. V. Fedorov, Leningrad Institute of Nuclear Physics imeni B. P. Konstantinov, USSR Academy of Sciences]

[Abstract] Diffraction of thermal neutrons by an alpha-quartz single crystal is analyzed, taking into account not only gravitation but also elastic forces bending the crystal. The problem is tackled theoretically by considering a plane-parallel slab cut from a nearly perfect single crystal and optical quartz so that the (hkl) planes, at which diffraction takes place, be perpendicular to the large facets and parallel to the lateral ones. These planes are assumed to be slightly bent by Kato forces concentrated along the supporting "knife edges." On this slab impinges a horizontal beam of nonpolarized thermal neutrons so that the Bragg condition is satisfied for neutrons with a 0.2 nm wavelength. They propagate through the crystal slab in Bloch waves corresponding to two modes, alpha and beta, then leave it in a forward beam and in one reflected after diffraction. The change in the pendulum pattern as the crystal slab is rotated into a reverse position relative to the vector of gravitational acceleration is evaluated, taking into account the trajectory of neutron beams and their interference as well as Kato forces and gravitation. The effect of gravitation on neutron diffraction by a bent crystal was detected in an experiment which had been designed for monitoring the pendulum pattern. The results validate extension of the dynamical theory of diffraction from the simple case of a straight crystal to the more difficult case of a bent one. Elastic bending of the crystal evidently leads to new effects not occurring when an undeformed one diffracts thermal neutrons in the gravitational field. The authors thank K. Ye. Kiryanov for fruitful discussions and consultations, A. Z. Andreyev, A. P. Bulkin, V. Ya. Kezerashvili, V. P. Kharchenkov, and A. F. Shchebetov for designing constructing the intrachannel neutron guide, A. I. Kurbakov and V. A. Trunov for monitoring the perfection of crystals in a gamma-diffractometer, V. a. Priemyshev and N. I. Timoshuk for constructing and installing the high-precision bending device, N. V. Polunin, L. E. Samsonov, and S. I. Khakhalin for designing and adjusting the electronic instrumentation, Yu. P. Platonov, V. V. Skorobogatov, and A. N. Litvinenko for assistance in producing and processing optical interferograms during measurements, and the personnel in charge of the VVR-M water-moderated water-cooled reactor at the Leningrad Institute of Nuclear Physics. Figures 4; references 10: 6 Russian, 4 Western.

UDC 539.123.17

**Effect of Rest Mass of Neutrino and of Antineutrino on Their Scattering by  $^{12}\text{C}_6$  Nucleus**  
18620032a Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 7, Jul 88 (manuscript received 13 Dec 85)  
pp 37-43

[Article by N. V. Samsonenko, Chkhotu Lal Katkhat, and A. I. El-Gavkhari, 'Amity of Nations' University imeni Patrice Lumumba]

[Abstract] The differential cross-sections for the scattering processes neutrino plus  $^{12}\text{C}_6$  yielding  $^{12}\text{N}_7$  plus electron and antineutrino plus  $^{12}\text{C}_6$  yielding  $^{12}\text{B}_5$  plus positron are calculated in accordance with the low-energy current-current theory of weak interaction and with the structure of a nucleus described by a multipole expansion of a weak nucleon current. Calculations are made first for nonpolarized leptons, electron and positron, as well as considering the possibility of their longitudinal polarization. The rest mass of a neutrino and of an antineutrino is then taken into account, its effect on these respective reactions being found to be very small but most pronounced at their thresholds. The authors thank B. K. Kerimov for discussion. References 11: 5 Russian, 6 Western.

UDC 539.1.01

**Nonstandard Formulation of Perturbation Theory for Green's Functions**  
18620032b Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 7, Jul 88 (manuscript received 16 Dec 85)  
pp 43-49

[Article by M. N. Aliyev and V. S. Tagiyev, Azerbaijan State University imeni S. M. Kirov]

[Abstract] Chains of equations of motion for Green's functions complicated by addition of a series of competing interaction Hamiltonians with small parameters to the Hamiltonian of the noninteracting system are considered, a simple method being proposed for mathematically correct breaking up of such a chain. The solution to such a chain of equations is sought by formal expansion into power series in the small parameters, equivalent to expansion of Green's function into series in poles, in accordance with the perturbation theory. The procedure is outlined generally and then demonstrated on a specific example: calculation of the mass operator of Green's two-dimensional nuclear spin function for diamagnetic crystals containing paramagnetic impurity ions, the total Hamiltonian consisting of seven components representing electron spins and nuclear spins, phonon fields, spin-phonon, and electron-electron, electron-nuclear, nuclear-nuclear spin-spin interactions respectively. References 6: Russian.

UDC 539.213:548-162

**Early Stages of Electrical Breakdown Initiated by Laser Radiation in Charged Glasses**  
18620032c Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 7, Jul 88 (manuscript received 16 Jul 86)  
pp 72-77

[Article by A. I. Akishin, N. V. Zelikin, L. S. Korniyenko, V. V. Radchenko, L. P. Trukhanova, and Yu. I. Tyutrin, Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov]

[Abstract] An experimental study was made concerning the kinetics of electrical breakdown initiated by laser radiation in a charged dielectric material and concerning the mechanism of such a breakdown initiation. Breakdown in various charged borosilicate, borolanthanide, and phosphate glasses was initiated with radiation of a YAG:Nd<sup>3+</sup>-laser at the 1064 nm wavelength, in a monopulse of 1 mJ energy and 15 ns duration, focused by a lens onto the frontal or a lateral surface or within the volume of a glass specimen. Glow of optically and electrically triggered discharges was recorded with a streak camera or through a photo-detector on a 6LOR oscillograph. The column of Lichtenberg figures terminated at the initiation point in the case of surface initiation and at the nearest surface in the case of volume initiation. Three possible mechanisms of breakdown initiation by laser radiation are examined for an interpretation of the results: shock wave with a steeply rising electrical conductivity of glass at its front, propagation of cracks with high acceleration to a high velocity, and plasma of a conductor inclusion in glass. A model of the breakdown evolution in such dielectric materials is proposed which includes the time delay from application of the breakdown voltage to beginning of current flow through the discharge gap, this model being validated by the experimental data. Figures 4; references 6: Russian.

**Amplification of Magnetostatic Solitons by Drift Flux of Charge Carriers in Ferromagnetic-Semiconductor Structure**

18620002b Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 12, 26 Jun 88 (manuscript received 1 Nov 87, in final version 28 Mar 88) pp 1090-1094

[Article by N. Ye. Vigdorchik and I. V. Ioffe]

[Abstract] The possibility of an envelope soliton of surface magnetostatic waves being amplified by an electron flux is demonstrated theoretically, the necessary condition being that the drift velocity of the electron flux exceed a certain threshold level. The proof is based on derivation of the corresponding parabolic nonlinear Schroedinger equation with complex coefficients for a dispersive medium such as a thin film of Y-Fe garnet on a semiconductor substrate by the Zvezdin-Popkov-Karpman method and its subsequent solution. Use is made of the dispersion equation  $G(k, \omega) = 0$ , the imaginary term for the amplitude of the magnetic field potential along with the real term for its rate of change being added to that Schroedinger equation. References 12: Russian.

### Diffraction Inversion of Wave Front

18620078c Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript  
received 30 Dec 87) pp 15-23

[Article by Yu. A. Afinogenov and Yu. G. Pavlenko,  
Moscow State University imeni M. V. Lomonosov]

[Abstract] At the present time perturbation theory is the basic method for computing Green's functions. In quantum theory, however, a nonperturbation approach is used which is based on the fifth parameter method. A general formalism for solution of Maxwell equations using complete Green's functions based on the fifth parameter method is therefore proposed. Calculations are given making it possible to predict a new phenomenon: an object wave, scattered by a smooth inhomogeneity, forms a conjugate image supplementing the main image. The two images are on different sides of the inhomogeneity and are simultaneously real or imaginary. The considered phenomenon has a wave nature; with passage to the limit  $\gamma \rightarrow 0$  the intensity of the conjugate image becomes equal to zero. References: 26 Russian.

### Precession Mechanisms of Light-Induced Quadrupole Moment of Ground State of Atoms With Superfine Structure in Weak Magnetic Field and Their Manifestations in Optical Characteristics

18620078d Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 11, Nov 88 (manuscript  
received 2 Feb 88) pp 24-32

[Article by M. V. Krashenninnikov, V. S. Smirnov, M. B. Sultanov, A. M. Tumaykin, and V. I. Yudin, Siberian State Scientific Research Metrology Institute]

[Abstract] A new physical effect of free and forced precession of an optically induced quadrupole moment in a weak magnetic field in the absence of a light-induced magnetic moment is examined. The problem is solved for the ground state of an atom with allowance for superfine splitting and Doppler broadening. Restriction of the light flux results in a qualitatively new behavior of precession relaxation processes. In order to detect this phenomenon it is proposed that still another new physical effect associated with rotation of the light polarization plane in a weak magnetic field be used. The article is restricted to the orientation of a circularly polarized field in order to draw attention to the new physical effect of precession of a quadrupole moment; precession of multipole moments oriented elliptically to a polarized field will be examined later. Figures 2; references 11: 10 Russian, 1 Western.

### Detection of Photomodification of Silver Clusters Selective With Respect to Wavelength and Polarization

18620092c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 10, 25 Nov 88  
(manuscript received 28 Sep 88) pp 528-531

[Article by S. V. Karpov, A. K. Popov, S. G. Rautian, V. P. Safonov, V. V. Slabko, V. M. Shalayev, and M. I. Shtokman, Automation and Electrometry Institute, Siberian Department, USSR Academy of Sciences; Physics Institute imeni L. V. Kirenskiy]

[Abstract] A nonlinear laser photomodification of silver clusters, selective with respect to light frequency and polarization, has been discovered. Three cluster media were investigated: aggregated silver hydrosols, Ag clusters in gelatin, Ag clusters in a gelatin layer of photoemulsion. The clusters were characterized by the appearance of a broad absorption band in the visible and near-IR regions. The clusters were irradiated by lasers using gigantic and ultrashort pulses and with quasicontinuous generation. It was found that with irradiation of the clusters by pulses interacting with their long-wave absorption band troughs appear in the absorption spectrum near the laser wavelengths. The width and shape of the trough are dependent on the method for preparing the clusters, the form of the buffer medium and the time interval between irradiation and registry of the spectrum. In the extinction spectrum of irradiated aerosols there is also an increase in absorption from the short- and long-wave directions. The width of the trough is close to the width of the absorption line of monomers in unaggregated hydrosol. The narrowest troughs were registered in the spectrum of clusters in a holographic photoemulsion; stable (for at least a month) troughs in the absorption spectrum were observed for clusters registered in gelatin. The depth and width of the trough increase with an increase in the number of irradiating pulses. The trough appears only in an absorption spectrum with the same plane polarization as for the laser pulse. There is no trough in an absorption spectrum with orthogonal polarization. Thus, the observed phenomenon is associated with photomodification of clusters with their local absorption of radiation of a specific frequency and polarization. Figures 3; References 6: 5 Russian, 1 Western.

UDC 548.734

### Measurement of Diffraction Scattering of X-Rays at Glancing Angles of Incidence Using Position-Sensitive Detector

18620096b Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 10, Oct 88 (manuscript received 14 Dec 87) pp 2881-2884

[Article by A. A. Lomov, D. V. Novikov, D. A. Goganov, and S. M. Gutkevich, Crystallography Institute, USSR Academy of Sciences, Moscow]

[Abstract] Despite its high resolution in crystal depth the asymptotic Bragg diffraction method (ABDM) has not

come into wide use because it requires the availability of both a three-crystal X-ray spectrometer and a large number of experimental measurements when investigating a single sample. The use of the ABDM method in a glancing Bragg-Laue geometry made it possible to simplify the measurement method. In this geometry the X-ray beam collimated by the Bragg angle forms a small angle with the crystal surface. At the same time the Bragg condition is simultaneously satisfied for a family of planes deflected slightly from the normal to the surface. It was found that the use of a position-sensitive detector for registry of differential diffraction curves in a Bragg-Laue glancing geometry without Bragg angle collimation makes it possible to convert to a single-crystal variant of the registry scheme and dispense with sample rotation in the measurement process, which considerably simplifies the method. The use of such a diffraction scheme with simultaneous registry of the entire tail of purely diffraction scattering makes it possible, from a single measurement, to ascertain the reduced intensity function in the ABDM. This considerably simplifies research on ultrafine surface layers of microcrystals and amorphous films on their surfaces. Figures 3; references 6: 5 Russian, 1 Western.

UDC 681.327.11:531.71.082.53

**Algorithm for Increasing Measurement Accuracy in Shadow Method**

18620111b Minsk VESTSI AKADEMII NAVUK BSSR: SERYA FIZIKA- MATEMATYCHNYKH NAVUK in Russian No 5, Sep-Oct 88 (manuscript received 11 Feb 88) pp 41-44

[Article by V. A. Pilipovich, A. K. Yesman, V. K. Kuleshov, V. P. Dubrovskiy, V. S. Posedko, and A. A. Savchenko, Electronics Institute, Belorussian Academy of Sciences]

[Abstract] In various practical applications known shadow method algorithms for measuring linear dimensions fail to meet measurement accuracy and range requirements. This article describes a shadow method algorithm eliminating these shortcomings applicable, in particular, to a linear CCD photodetector array. Data are needed on the distribution of amplitudes of CCD array output signals and it is necessary to apply effective methods for digital processing of videosignals. This is possible using the described algorithm in simple microprocessor processing. The algorithm for determining image size is divided into the following steps: data accumulation and preprocessing; detection of image boundaries; determination of "comparison threshold," the level at which image size is determined; refinement of position of image boundaries by interpolation of its fronts and computation of size. Data accumulation is

accomplished by multiple CCD interrogation with subsequent averaging of results, making it possible to obtain a statistically stable quantized videosignal. Figures 2; references: 9 Russian.

UDC 535.853

**Underwater Multichannel Fluorimeter for Marine Ecological Research**

18620099c Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 49 No 3, Sep 88 (manuscript received 9 Apr 87) pp 515-518

[Article by G. S. Karabashev and S. A. Khanayev]

[Abstract] Several types of submersible fluorimeters are in use but do not fully correspond to the latest needs of oceanology, which requires rapid simultaneous measurement of fluorescence and oceanological characteristics. There has been need for an instrument in which all the measurement channels are integrated in a data collection and registry system. The described instrument, the MZF submersible fluorimeter, fills this need: it is for synchronous determination of the vertical profiles of fluorescence of chlorophyll and dissolved organic matter, light scattering and other hydrophysical characteristics in the oceanic active layer at depths from 0 to 250 m. The fluorescence and light scattering are excited simultaneously by a flash lamp and are registered separately by three photometers. The digital system for data collection transmits information from 8 optical and hydrophysical sensors through a single-strand supporting-electrical cable to the ship where the data are registered by a curve plotter, multichannel automatic recorder and magnetic recorder and processed using a microcomputer. The possibilities of the instrument are illustrated in the example of fine-structured fluorescence and temperature inhomogeneities. Figure 1; references: 5 Russian.

UDC 535.317.1

**Shift Selectivity of Holograms With Reference Speckle Wave**

18620103d Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 65 No 3, Sep 88 (manuscript received 10 Aug 87) pp 661-665

[Article by A. M. Darskiy and V. B. Markov]

[Abstract] A theoretical and experimental study was made of transverse shift selectivity of holograms with a reference speckle wave, determined by the autocorrelation function of the latter. The speckle wave was formed by a diffuser-lens system. The degree of shift selectivity is determined by the parameters of the optical system, especially the diffuser-lens distance. An experimental study was made of the influence of this distance on shift selectivity. It is shown that the autocorrelation function of the speckle pattern formed in an arbitrary plane behind the lens is dependent on such parameters of the optical system as the width of the beam incident on the



diffuser, the diffuser-lens distance and lens focal length. With a change in the diffuser-lens distance the width of the autocorrelation function changes nonmonotonically and has a minimum in a case when the plane of registry is situated in the image plane of the scatterer. By changing the distance between the diffuser and the lens it is possible to control the width of the autocorrelation function of the speckle pattern, and if such a speckle pattern is used as a reference pattern when registering the hologram, also control the shift selectivity of the latter. Figures 3; references 7: 5 Russian, 2 Western.

**Exciton Absorption During Passage of Light Through AlGaAs Double Heterostructure With Quantum-Dimensional Layer Acting as Waveguide**  
18620069a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 17, 12 Sep 88 (manuscript received 4 May 88) pp 1548-1552

[Article by R. P. Seysyan, A. A. Toropov, V. R. Lari-onov, V. P. Khvostikov, T. V. Shubina, and I. L. Aleynier, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of exciton absorption in a waveguide formed by an AlGaAs/GaAs double heterostructure with a quantum-dimensional interlayer during passage of light was made, such structures having been produced by the method of liquid-phase epitaxy at a temperature below 550 deg C so as to ensure slow crystallization at a rate below 0.5 nm/s and thus facilitate controlling the thicknesses of layers with high precision. The waveguide thickness was varied over the 400-900 nm range, with a 10-16 nm thick quantum-dimensional layer in the middle and a p-n junction formed parallel to it at distances of 100-200 nm from it. Contacts with both p and n regions were formed by deposition of Au(Ge) and Au(Ni) electrodes respectively. The light source was an InGaAs/InGaAsP heterojunction laser with a diffraction grating as selective external cavity. Four-split and double-mesa specimens were tested for electrooptical properties. Light absorption as well as exciton absorption spectra were recorded, also photocurrent spectra and dependence of the transmittance on the bias voltage across the heterostructure. Figures 2; references 6: 3 Russian, 3 Western.

**Formation of Ordered Structure in Albumin Film During Desiccation**  
18620069c Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 17, 12 Sep 88 (manuscript received 17 May 88) pp 1560-1565

[Article by Ye. G. Rapis, Turkmen Scientific Research Institute of Eye Diseases]

[Abstract] An ordered structure in albumin films was discovered during their desiccation, solutions of bovine and chicken albumin as well as of serum albumin and

globulin along with a solution of human hemoglobin having been used in the experiment. It was a "desiccation rosette" split into segments by a regular array of cracks. A wave process was found to evolve from a quiescent center at a geometrically proper site within each segment, producing an array of "cells" with a "nucleus" each and each surrounded by spiral cracks. Altogether 150 tests were performed, equally large drops of albumin film from the five different solutions being each time placed on the object glass of a "Biolam" optical microscope and photographed every 5-15 minutes during desiccation at a temperature of 26 deg C. The number and the symmetry of segments as well as the number and the configuration of spirals around their centers depended largely on the albumin concentration and also on the degree of albumin preservation in storage. The morphology of the "desiccation rosette" depended also on the temperature, its structurization peculiar to albumins, commensurate with the concentration of albumin and with the perimeter of drop during desiccation of biological media such as sera or tears, was subsequently utilized for quantitative and qualitative determination of albumin in medical practice. Absence of superposition and interference effects indicates that an autowave process is involved here. The morphology of dried albumin film is thus evidently determined by morphogenesis and self-adaptation, which generally characterize the molecular structure of albumin at various levels. Further study of the "desiccation rosette" may, therefore, lead to discovery of some common features during phase transitions of albumins. The author thanks M. Ya. Amus and M. I. Klinger for helpful discussions. Figures 3; references 1: Russian.

**Frequency Autoconversion in and Reflectionless Propagation of Electromagnetic High-Frequency Pulse Under Breakdown Conditions**  
18620068a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 18, 26 Sep 88 (manuscript received 12 Jun 88) pp 1695-1698

[Article by V. B. Gildenburg, V. A. Krupnov, and V. Ye. Semenov, Institute of Applied Physics, USSR Academy of Sciences, Gorkiy]

[Abstract] Ionizing frequency autoconversion in a plane electromagnetic pulse, a plane electromagnetic wave cut off by the high-frequency breakdown plasma it has generated, is analyzed theoretically in three specific situations which reveal new possibilities of stepping up the frequency of a signal wave to a high level, attaining plasma frequencies much higher than the frequency of a signal wave propagating without reflections, and complete prevention of signal cutoff under breakdown conditions. The analysis is based on a system of three balance and transfer equations, in the approximation of geometrical optics, for "ultra-strong" quasi-harmonic electric fields. The three cases are homogeneous discharge produced by a homogeneous plane wave, the



initial-value problem of an electromagnetic pulse of semi-infinite duration, and injection of an electromagnetic pulse into an ionizable medium. References 6: 4 Russian, 2 Western.

**Determination of Parameters of Thin-Film Fiber Optics**

18620068b Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 18, 26 Sep 88 (manuscript received 8 Jul 88)  
pp 1698-1701

[Article by E. A. Arutyunyan, S. Kh. Galoyan, and S. P. Pogosyan, Institute of Physics Research, ArSSR Academy of Sciences, Ashtarak]

[Abstract] Analytical expressions are derived for three parameters of thin-film fiber optics necessary for determining the index profile, these expressions being approximate but sufficiently accurate for manual engineering design calculations. They are applicable to multimode fiber optics with at least two resonance modes and particularly those with a stepped index. They are based on the assumption that  $n_{m-1}^2 - n_s^2$  is approximately equal to  $n_f^2 - n_o^2$  ( $n_m$  - effective refractive index for m-th mode,  $n_f, n_s$  - refractive indexes of carrier film and of substrate respectively). By successive approximations, with the appropriate choice of the zeroth approximation ( $n_s^{(0)}$  approximately equal to  $n_{m-1}$ ), they yield the waveguide thickness  $h$  along with  $n_f$  and  $n_s$ . Tables 1; references 3: 1 Russian, 2 Western (1 in Russian translation).

UDC 535.36

**Asymptotic Model Describing Light-Scattering Characteristics of Fractal Clusters**

18620050 Moscow DOKLADY AKADEMII NAUK  
SSSR in Russian Vol 312 No 2, Sep 88 (manuscript received 6 Jul 87) pp 332-334

[Article by V. N. Kuzmin, O. V. Moroz, and A. P. Prishivalko, Institute of Physics, BSSR Academy of Sciences, Minsk]

[Abstract] A model of a radially nonhomogeneous spherical particle is proposed for description of the light-scattering characteristics of fractal clusters, considering that the density of such a cluster is inversely proportional to  $r^{3-D}$  where  $r$  denotes the distance from a selected cluster center much larger than the radius of a cluster particle and  $D$  denotes the fractal dimensionality. Inasmuch as particles in a fractal cluster are small, only the dipole properties of scattered light need to be taken into account for calculation of both refractive and absorption indexes of such a cluster. In this approximation of an effective medium this model reduces to the Maxwell-Garnett model and becomes an asymptotic one applicable to molecular optics of gases and dilute solutions. With the optical properties of a fractal cluster at its periphery describable and the percolation threshold of metal-to-dielectric transition determinable on this basis, one possible optical model of a fractal cluster is a spherical particle consisting of a homogeneous on-the-average core inside a radially nonhomogeneous shell. Article was presented by N. A. Borisevich on 12 June 1987. References 7: 5 Russian, 2 Western (1 in Russian translation).

UDC 533.951

**Rotational Instability of Charged Plasma in Crossed Perpendicular E/H Fields and Generation of Electrons of Anomalous High Energy**

18620128a Moscow FIZIKA PLAZMY in Russian  
Vol 15 No 2, Feb 89 (manuscript received 5 Jan 87,  
after revision 2 Feb 88) pp 174-181

[Article by N. A. Kervalishvili, Physics Institute, Georgian Academy of Sciences]

[Abstract] Research was carried out in a magnetron geometry of a discharge instrument, making it possible to establish a correlation between rotational oscillations and electrons of anomalously great energy and to find the mechanisms of their generation. Rotational oscillations are usually observed using electrostatic probes situated on the plate surface, but such measurements are inadequate for determining the parameters of rotating inhomogeneities. The apparatus, illustrated in a figure and described in the text, was devised for this purpose. The working gas was argon. The discharge instrument plate and cathode were water-cooled. The experiments were carried out in a uniform magnetic field parallel to the discharge instrument axis. Two mechanisms of generation of electrons of anomalously high energy were discovered in charged plasma of the anode layer in crossed perpendicular E/H fields. Each of these mechanisms predominates in a definite range of working gas pressures. Despite extremely significant differences, the two mechanisms, which are described in detail, lead to identical results. Figures 5; references 14: 9 Russian, 5 Western.

UDC 533.9.08

**Radiation of Hard Electrons From Laser Plasma in 'Delfin' Apparatus**

18620128b Moscow FIZIKA PLAZMY in Russian  
Vol 15 No 2, Feb 89 (manuscript received 12 Jun 87,  
after revision 9 Mar 88) pp 244-246

[Article by F. A. Nikolayev, S. F. Roslik, O. I. Stukov, Ye. G. Gamaliy, Yu. A. Mikhaylov, V. B. Rozanov, G. V. Sklizkov, S. I. Fedotov, and S. A. Shumskiy, Moscow Aviation Institute; Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] The energy yield of hard electrons in the energy range greater than 300 KeV was measured in the "Delfin" apparatus with the irradiation of spherical shell high-frequency targets by laser radiation pulses  $2 \times 10^{-9}$  s with an energy about  $10^3$  J. A sharp cutoff of the spectrum of fast electrons with energies about 300 keV was experimentally observed. Such a form of the distribution function is characteristic for fast electrons accelerating during multiple interaction with resonance plasma oscillations in the presence of magnetic fields. The influence of magnetic fields is maximal for the "tail" of the electron distribution function. The number of

interactions with the resonance fields induced by the magnetic field is considerable even for not very strong fields. A practical limitation on the maximal energy of the fast electrons is imposed by the dimensions of the magnetic field: acceleration ceases when the Larmor radius of an electron is comparable to the distance from the acceleration region to the field boundary. An expression is derived for maximal energy for such a generation mechanism which makes it possible to obtain information on magnetic fields in laser targets. Figures 2; references: 1 Russian.

UDC 533.9.08

**Optimal Experiment for Research on Semi-Self-Maintained Discharge**

18620095c Tomsk IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 10, Oct 88 (manuscript received 27 Feb 87)  
pp 43-48

[Article by V. A. Ivanov and I. V. Makasyuk, Leningrad State University]

[Abstract] An experiment carried out for investigating a semi-self-maintained discharge meeting the requirement of the most effective accumulation of information on processes transpiring in plasma with an electrical field is described. The basis for this research was a method for ensuring the required temporal variation of electrical field strength  $E(t)$  in plasma in combination with an optimal system for registry of the experimentally measured values. The results of investigation of the plasma of a semi-self-maintained discharge at pressures of several tens of mm Hg in a He-Xe mixture are presented, demonstrating the possibilities of the proposed experimental scheme. There is no apparent reason why such experiments cannot be carried out for studying plasma generated by an electron beam at considerably greater gas pressures. Figures 4; references: 7 Russian.

UDC 533.9

**New Integral Equations for Systems With Coulomb Interaction**

18620055 Minsk DOKLADY AKADEMII NAUK BSSR  
in Russian Vol 32 No 10, Oct 88 (manuscript received  
14 Dec 87) pp 899-902

[Article by V. V. Belov, Belorussian Institute of Technology imeni S. M. Kirov]

[Abstract] Integral equations for a system with Coulomb interaction are derived without use of a small parameter. The system is necessarily a two-component one, since its stability hinges on its electrical neutrality, and at the thermodynamic limit requires corrections in its description which will account for the specifics of the particle-particle interaction. The equations are reduced to a form allowing their solution by the method of successive approximations, after terms representing "bare" static

interaction and its "sheath" have been explicitly extracted and Fourier transformation of both sides has been made possible. Then, following transformation into equivalent equations without the Coulomb potential excluded but with shielded Yukawa potentials instead, solution of these equations by iterations beginning with the free terms as initial approximation will yield not only the binary distribution functions but also the free energy of the system and thus all its thermodynamic properties without any constraints on its density or temperature. Article was submitted by Academician (BSSR Academy of Sciences) R. I. Soloukhin. References 4: 3 Russian, 1 Western (in Russian translation).

UDC 533.932

**Breakdown of Jet of Molecular Vapor in Laser Irradiation of Nonmetallic Materials**

18620105b Moscow *TEPLOFIZIKA VYSOKIKH TEMPERATUR* in Russian Vol 26 No 5, Sep-Oct 88 (manuscript received 17 Dec 87) pp 852-858

[Article by V. S. Vorobyev and S. V. Maksimenko, High Temperatures Institute, USSR Academy of Sciences]

[Abstract] A study was made of the stationary state of molecular vapor near a surface heated by a laser. Conditions are examined when the velocity of vapor flow near the surface is close to the local speed of sound. The one-dimensional problem of supersonic flow of vapor is

solved for short distances from the surface with allowance for the absorption of laser radiation. At great distances, where the flow has a three-dimensional character, it is possible to neglect the absorption of laser radiation. This circumstance makes it possible to evaluate the parameters of the vapor behind the front of a stationary shock wave, the so-called "hanging jump." Under some conditions the temperature of the vapor behind the front is sufficiently high for the development of an ionization-thermal explosion, a breakdown. References 7: 6 Russian, 1 Western.

**Plasma Condensation in Fluctuating Strong Magnetic Field**

18620040e Moscow *ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI* in Russian Vol 94 No 9, Sep 88 (manuscript received 4 Feb 88) pp 89-99

[Article by V. S. Gorbachev and S. R. Kelner, Moscow Institute of Engineering Physics]

[Abstract] A new method of solving equations of magnetohydrodynamics in the approximation of a strong magnetic field is outlined, its gist being use of frozen-in coordinates, and then applied to the problem of plasma flow near an alternating dipolar magnetic field. Analysis of the solution reveals that magnetic bunching can be caused not only by increases and decrease of the magnetic moment but also by its fluctuation, the latter being the likely cause of plasma condensation in the form of solar protuberances. Figures 2; references 12: 10 Russian, 2 Western (1 in Russian translation).

**Distribution of Local Currents in Disordered Conductors**

18620113c Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 95 No 1, Jan 89 (manuscript  
received 15 Jun 88) pp 253-260

[Article by I. V. Lerner, Spectroscopy Institute, USSR  
Academy of Sciences]

[Abstract] The current density distribution function in disordered conductors is investigated within the framework of renormalized group analysis. It is shown that within the region of weak localization the distribution of typical fluctuations is Gaussian and the probability of great intensity fluctuations decreases lognormally. The lognormal part in the distribution is considerably more substantial than in the distribution function for conductances and increases with an increase in the quantum corrections. In a region where the mean conductivity is essentially determined by quantum corrections the distribution is completely lognormal. It was also found that whereas typical fluctuation currents are not correlated in direction with the external electrical field  $E$ , great fluctuation currents are directed for the most part coaxially with  $E$ . Figure 1; references 20: 12 Russian, 8 Western.

**Polaron Theory of High-Temperature Superconductors**

18620113d Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 95 No 1, Jan 89 (manuscript  
received 24 Jun 88) pp 296-300

[Article by A. S. Aleksandrov, Moscow Physical Engineering Institute]

[Abstract] It is shown that the theory of strong electron-phonon interaction, taking the formation of small polarons and bipolarons into account, satisfactorily describes the main properties of high-temperature superconductors containing metallic oxides. HTSC metallic oxides such as LBCO, LSCO, YBCO, Bi-Sr-Ca-Cu-O, Tl-Ba-Ca-Cu-O, SrTiO<sub>3</sub>, Ba-Pb-Bi-O, LiTiO<sub>2</sub>, K-Ba-Bi-O and others are bipolar superconductors which can be described by the polaron theory of superconductivity. The measurable isotopic effect (20), tunnel spectroscopy, zone computations and other experiments support an electron-phonon mechanism of interaction in HTSC. The polaron theory of HTSC explains high  $T_c$  exclusively as a result of a suitable combination of the initial width of the electron zone  $D$  and the constants of electron-phonon interaction  $g^2$ . Accordingly, a complex structure, as well as the presence of copper, is not very important for high  $T_c$  values. Figures 2; references 19: 6 Russian, 13 Western.

**Thermodynamic and Magnetic Properties of System of Superconducting Twinning Planes**

18620113e Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 95 No 1, Jan 89 (manuscript  
received 9 Jun 88) pp 371-383

[Article by A. A. Abrikosov, A. I. Buzdin, M. L. Kulich, and D. A. Kuptsov, Moscow State University imeni M. V. Lomonosov]

[Abstract] A study was made of the influence of a system of twinning boundaries with local intensification of superconducting pairing on the thermodynamic characteristics of the superconducting transition. The dependence of the heat capacitance of such a system on temperature is computed. The results are compared with measurements of the heat capacity of monocrystals of the high-temperature superconductor YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-d<1</sub>. Above the critical temperature of the bulk transition there is a Josephson interaction of the superconducting twinning planes. The behavior of the upper and lower critical fields in this region was investigated. The force of interaction of the superconducting vortex with the twinning plane is determined and the role of this interaction in the pinning of vortices is discussed. Figures 3; references 29: 17 Russian, 12 Western.

**Raman Light Scattering in La<sub>2-x</sub>Sr<sub>x</sub>CuO<sub>4</sub>**

18620091a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 1, 10 Jan 89 (manuscript  
received 17 Nov 88) pp 16-18

[Article by Yu. S. Ponosov and G. A. Bolotin, Physics of Metals Institute, Ural Department, USSR Academy of Sciences]

[Abstract] Measurements of spectra of Raman light scattering (RLS) were made in a tetragonal monocrystal of the composition La<sub>1.83</sub>Sr<sub>0.17</sub>CuO<sub>4</sub> and also in ceramic samples with different strontium contents ( $x = 0.05-0.4$ ) obtained by the solid phase synthesis method. The spectra were excited by the lines of an argon laser with a power up to 200 mW with glancing incidence on the mechanically polished surfaces of the samples. The scattered light was registered by a spectrophotometer. Observations in polarized light revealed rather large monocrystals in some samples. Orientation of the  $c$  axis was established by x-ray diffraction and the strontium content was about  $x = 0.17$ . All three lines (153, 221 and 431 cm<sup>-1</sup>) observed earlier in ceramics belong to symmetric oscillations of the A<sub>1g</sub> type associated with displacements of atoms along the  $c$  axis. All the observed lines have anisotropic scattering tensors. The line intensities exhibit different behavior with a change in  $x$ . RLS spectra for monocrystals are given for different components of the scattering tensor, as well as for different Sr contents. There is a correlation between the intensity of the A<sub>1g</sub> modes at 221 cm<sup>-1</sup> and 431 cm<sup>-1</sup> and the temperature of the superconducting transition. Figures 2; references 14: 2 Russian, 12 Western.

**Raman Light Scattering in Monocrystals of Superconductors Tl-Ba-Cu-O**

18620091b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 49 No 1, 10 Jan 89 (manuscript  
received 8 Dec 88) pp 58-61

[Article by L. V. Gasparov, V. D. Kulakovskiy, O. V. Misochko, V. B. Timofeyev, N. N. Kolesnikov, and M. P. Kulakov, Solid State Physics Institute, USSR Academy of Sciences]

[Abstract] The results of experimental research on Raman scattering in monocrystals of  $\text{TlBa}_2\text{CaCu}_2\text{O}_{7-x}$  (Tl-1212) and  $\text{Tl}_2\text{Ba}_2\text{CaCu}_2\text{O}_{8-x}$  (Tl-2212) are presented. The monocrystals were grown by slow cooling from a melt of stoichiometric composition in an oxygen flow and had the form of rectangular platelets with a mirror basal plane. The Tl-1212 and Tl-2212 samples exhibited a transition to a superconducting state at  $T = 70$  and  $110$  K respectively. The Raman scattering spectra for different monocrystal surfaces were registered in a backscattering geometry. The radiation of an  $\text{Ar}^+$  laser was focused on the sample in a  $3\mu\text{m}$  spot. The intensity of the laser radiation did not exceed several mW in order to avoid overheating of the excited region. The investigated crystals each contained two Cu-O layers separated by planes of Ca ions. The Raman scattering polarization spectra for these monocrystals are illustrated in Figures 2 and 3. The  $A_{1g}$  oscillations of metallic ions and oxygen are discussed. The number of observed  $A_{1g}$  modes in the studied crystals coincides with the number of modes found from theoretical group analysis. Figures 3; references 10: 2 Russian, 8 Western.

UDC 535.375.5

**Nonlinear Bisoliton Model of Superconductivity**

18620042 Kiev DOKLADY AKADEMII NAUK  
UKRAINSKOY SSR, SERIYA A: FIZIKO-  
MATHEMATICHESKIYE I TEKHNIЧЕСKIYE  
NAUKI in Russian No 9, Sep 88 (manuscript received  
29 Apr 88) pp 48-52

[Article by Academician A. S. Davydov, Institute of Theoretical Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] On the author's earlier premise that the high-temperature superconductivity of the new ceramic materials such as  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  involves only quasi-one-dimensional chains of moving copper and oxygen ions, a model of this superconductivity is constructed which includes pairing of quasiparticles in these chains near the Fermi surface into bisolitons (bosons). These bisolitons carry a double electric charge, have a zero spin, and their energy is that of chain deformation through electron-phonon interaction. Their motion along a Cu-O chain is described by a system of three coupled nonlinear equations for two quasiparticle fields and the strain field. The solutions, which describe a bisoliton condensate, are periodic and expressible in terms of Jacobian elliptic

functions. According to this model, the lowest possible quasiparticle concentration is most favorable for superconductivity and this condition, together with the correlation length based on experimental data, yields the value of the g-factor corresponding to specific values of the lattice parameter. The presence of a bisoliton condensate is a necessary but not sufficient condition for superconductivity, since the stability of a slowly moving bisoliton condensate requires the absence of other one-particle sources of excitation energy below the bisoliton energy level and that the Landau condition for superfluidity be satisfied. The velocity of a fast-moving bisoliton condensate cannot exceed the velocity of sound in the same direction or the group velocity of free quasiparticles in the conduction band, whichever is lower. There is also a critical velocity above which a bisoliton will decay into its two constituent quasiparticles. References 5: 3 Russian, 2 Western.

**Phase Transition of Granular Superconductor Films**

18620072a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 6, 25 Sep 88 (manuscript  
received 20 Jun 88) pp 323-325

[Article by Ye. A. Antonova and V. L. Ruzinov, Moscow Institute of Steel and Alloys]

[Abstract] Experimental data on temperature-related and current-related transition of granular NbN films from normal to superconducting state are analyzed and evaluated on the basis of the percolation theory, taking into account weakness of links between columnar NbN grains responsible for fluctuations of the phase transition temperature. The data include the temperature dependence of the electrical resistance of a square film and dependence of the critical superconducting transition temperature  $T_c$  on that resistance, measurements having been made over the 300-4.2 K range. Extrapolation of the critical temperature to absolute zero, its resistance dependence being an exponential one, yields for a square film at that temperature a resistance of 6455 ohms and thus slightly higher than  $h/4e^2$ . The data include also the temperature dependence of the field period which characterizes the oscillatory field dependence of the critical temperature and of the critical current as well as of the resistance, on the basis of these data having been calculated the temperature dependence of the critical current and of the distance between critical links in a film. The results indicate a wide temperature range of superconducting transition, superconductivity fluctuations being followed by transition of individual granules and that being followed by buildup of superconducting clusters as the temperature drops from above to below  $T_{co}$ . Figures 3; references 8: 4 Russian, 4 Western (1 in Russian translation).

**Acoustical Characteristics of  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$  ( $x$ : 0,0.2) and  $\text{YBa}_2\text{Cu}_3\text{O}_y$  ( $y$ : 6,7) and Anomalies in Their Lattice Vibration Spectra**

18620072b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 6, 25 Sep 88 (manuscript  
received 21 Jul 88) pp 326-329

[Article by V. I. Makarov, N. V. Zavaritskiy, V. S. Klochko, A. P. Voronov, and V. F. Tkachenko, Institute of Problems in Physics, USSR Academy of Sciences, and Kharkov Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] An experimental study of  $\text{La}_2\text{CuO}_4$ ,  $\text{La}_{1.8}\text{Sr}_{0.2}\text{CuO}_4$  and  $\text{YBa}_2\text{Cu}_3\text{O}_6$ ,  $\text{YBa}_2\text{Cu}_3\text{O}_7$  superconductor compounds was for the first time made for a determination and analysis of their acoustical characteristics. Both velocity and attenuation of sound in ceramic specimens and in single crystals were measured by the standard pulse method at 20 MHz and 50 MHz frequencies with pulses of 1000-1500 ns duration, at temperature from 200 K to below the critical. Anomalies were found in the temperature dependence of both velocity and attenuation, not sensitive to change in the material composition ( $x$  from 0 to 0.2,  $y$  from 6 to 7) and evidently caused by interaction of sound and soft optical modes in the lattice. Figures 3; references 16: 4 Russian, 12 Western (1 in Russian translation).

**Anisotropy of Electron-Paramagnetic-Resonance Absorption in Single Crystals of R-Ba-Cu-O Superconductors (in Weak Magnetic Fields)**

18620072c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 6, 25 Sep 88 (manuscript  
received 29 Jun 88) pp 338-341

[Article by Yu. I. Vesnin, V. Ye. Istomin, and E. G. Kostsov, Institute of Atomation and Electrometry and Institute of Inorganic Chemistry, Siberian Department, USSR Academy of Sciences]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  and  $\text{ErBa}_2\text{Cu}_3\text{O}_{7-d}$  single crystals was made concerning their anomalously strong absorption of microwave radiation during their EPR-spectroscopy in weak magnetic fields. Specimens for this study were grown by the method of spontaneous crystallization from molten solution, 0.07-0.2 mm thick crystals 3-4 mm wide and 4-6 mm long with the C-axis normal to their faces and with the critical superconducting transition temperature within the 92-90 K range. Measurements were made with a radiospectrometer, the klystron operating at a frequency of 9.3 GHz with a modulation frequency of 0.975 MHz, the  $H_{011}$ -mode being excited in a cylindrical cavity at a temperature of 77 K. A crystal was placed in an antinode of the magnetic field, with its C-axis variously oriented relative to the constant magnetic field of up to 0.045 T intensity from parallel to perpendicular to the latter. A crystal was rotated about its C-axis as well as about axes

parallel to the constant magnetic field and to the magnetic component of the microwave field respectively. The amplitude of the EPR-signal and the form of the absorption line were found to be highly sensitive to the crystal orientation relative to the constant magnetic field, no signal at all appearing during rotation of the crystal while its C-axis remained parallel to the constant magnetic field and an EPR-signal appearing but its amplitude remaining constant during rotation of the crystal while its C-axis remained parallel to the alternating magnetic field. No such sensitivity was noted in the case of ceramic control specimens of identical geometrical dimensions and chemical composition with the same range of critical superconducting transition temperature. Scanning a crystal with the constant magnetic field at a rate of 50 Hz yielded a much wider loop of EPR-signal hysteresis, 0.004-0.006 T, than did scanning of ceramic specimens. The authors thank L. P. Kozeyeva and A. A. Pavlyuk for supplying the single crystals. Figures 3; references 16: 10 Russian, 6 Western.

**Localization of Electrons at Type-2 Heterojunction**

18620072d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 6, 25 Sep 88 (manuscript  
received 4 Aug 88) pp 342-344

[Article by A. N. Baranov, A. A. Guseynov, A. A. Rogachev, A. N. Titkov, V. N. Cheban, and Yu. P. Yakovlev, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences]

[Abstract] An experimental study of structures with type-2 heterojunctions such as  $\text{p-Ga}_{1-x}\text{In}_x\text{As}_y\text{Sb}_{1-y}/\text{p-GaSb}$  structures has for the first time revealed localization of electrons and their recombination with holes at the two-dimensional potential well of the heterojunction. Specimens of  $\text{p-Ga}_{0.8}\text{In}_{0.2}\text{As}_{0.18}\text{Sb}_{0.82}/\text{p-GaSb}$  structures were produced by liquid-phase epitaxy, 0.0015 mm thick  $\text{p-GaInAsSb}$  layers having been doped with Ge as acceptor impurity to various concentrations of the latter within the  $10^{17}$ - $10^{18} \text{ cm}^{-3}$  range and deposited on pure  $\text{p-GaSb}$  substrates with an intrinsic acceptor concentration of  $2 \cdot 10^{17} \text{ cm}^{-3}$ . These structures were exposed on the  $\text{p-GaInAsSb}$  side to radiation of a He-Ne laser at the 0.815 eV quantum energy level. Their luminescence spectra were recorded at a temperature of 4.2 K and found to include a second peak, on the low-energy side of the A-peak corresponding to interband transitions in the narrow-band  $\text{GaInAsSb}$  layer, this second peak coming closer to the A-peak as the excitation energy was increased and thus being obviously associated with localization of photoelectrons at the potential well of the heterojunction. Measurements in an external magnetic field variously oriented relative to the heterostructure revealed a two-dimensionality of the electronic states, the second peak shifting to higher energy levels in a transverse magnetic field proportionally to the intensity of the latter and not significantly shifting at all but decreasing in a parallel one. Meanwhile, the A-peak shifted appreciably and equally in a transverse magnetic field and in a parallel one. Evidently a magnetic field slows

down the diffusion of electrons toward a type-2 heterojunction and thus increases the concentration of electrons within the bulk of the doped layer. An analysis of the energy level diagram indicates, furthermore, that electrons localized at such a heterojunction can recombine with holes on both sides of the latter. The probability of recombination within the doped layer increases with higher acceptor impurity concentration, which corresponds to a higher hole concentration and to a shallower potential well allowing the wave function of electrons to penetrate deeper. Figures 3; references 3: Western (1 in Russian translation).

### Splitting of Energy Gap in Two-Dimensional Superconductor Without Inversion Center

18620072e Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 6, 25 Sep 88 (manuscript  
received 22 Jul 88, after revision 22 Aug 88) pp 357-359

[Article by V. M. Edelshteyn, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] The multilayer electronic structure of superconductor materials with a two-dimensional defect or without an inversion center is analyzed, of interest being materials with a large unit cell and especially one containing an even number of conduction planes with many extrinsic atoms and ions between them. The configuration of ions on both sides of a conducting layer is not necessarily symmetric relative to the latter and the tunneling interaction of conduction layers is assumed to be weak. The analysis is based on the electron Hamiltonian, which acquires a spin-orbital component upon loss of ion symmetry, and on the equations of motion for Green's functions at temperatures below the critical. Solution of these equations for all Green's functions yields a difference between two energy gaps on two Fermi circles and a dynamic break of symmetry with unequal excitation energy levels for quasiparticles with different helicities but without a split of the superconducting transition in terms of critical temperature and order parameter. References 6: 3 Russian, 3 Western.

### Effect of Twinning on Superconducting Transition Temperature for Beta-(ET)<sub>2</sub>X Organic Metals

18620040f Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript  
received 22 Feb 88) pp 277-282

[Article by A. V. Zvarykina, M. V. Kartsovich, V. N. Laukhina, Ye. E. Laukhina, R. B. Lyubovskiy, S. I. Pesotskiy, R. P. Shibayeva, and I. F. Shchegolev, Institute of Chemical Physics, USSR Academy of Sciences]

[Abstract] An experimental study of three isostructural organic metals beta-(ET)<sub>2</sub>X was made concerning the role of plastic deformation caused by twinning in the rise

of their superconducting transition temperature, considering that beta-(ET)<sub>2</sub>I<sub>3</sub> but not beta-(ET)<sub>2</sub>IBr<sub>2</sub> and beta-(ET)<sub>2</sub>AuI<sub>2</sub> undergoes complete superconducting transition under higher pressure. Single crystals of beta-(ET)<sub>2</sub>I<sub>3</sub> with a critical temperature of 1.4 K were produced by oxidation of ET with elementary iodine in a nitrobenzene solution to an ET:I<sub>2</sub> molar ratio of 1:0.5 and subsequent extraction from the solution by slow cooling from 80 deg C to room temperature at a rate of 1.5 deg/h or 0.5 deg/h. Single crystals of beta-(ET)<sub>2</sub>IBr<sub>2</sub> with a critical temperature of 2 K were produced by electrocrystallization and by chemical oxidation of ET. Single crystals of beta-(ET)<sub>2</sub>AuI<sub>2</sub> were produced by electrochemical oxidation of ET. All single crystals were plastically deformed by either uniaxial or omnilateral but not hydrostatic compression, the pressure being raised to several megabars at both 295 K and 78 K temperatures. Subsequent electrical resistivity measurements in a magnetic field, with the crystals rotated so that the two-dimensional anisotropy of their properties would also be taken into account, indicate a rise of the critical temperature to approximately 8 K for beta-(ET)<sub>2</sub>I<sub>3</sub> and only be 20-30 pct for the other two organic metals. While the small rise in the latter case is evidently attributable to the direct effect of twinning, the large rise for beta-(ET)<sub>2</sub>I<sub>3</sub> is evidently caused by formation and stabilization of the high-pressure beta<sub>H</sub>-phase under normal pressure owing to local stresses. Figures 5; references 17: 10 Russian, 7 Western.

### Quasiparticle Current in Superconductor-Semiconductor-Superconductor Sandwich

18620040g Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 9, Sep 88 (manuscript  
received 6 Apr 88) pp 353-367

[Article by A. V. Tartakovskiy and M. V. Fistul, Moscow Institute of Steel and Alloys]

[Abstract] Current flow in a superconductor-semiconductor-superconductor sandwich is analyzed, for an explanation of the anomalous current rise under high voltage. The total current density, characterized by the Keldysh-Green function, is calculated on the basis of Gorkov equations describing interaction of electrons with electrons and with other quasiparticles. The procedure is applied first to a normal sandwich with a semiconductor interlayer and then to a superconducting sandwich with such an interlayer. The results indicate that the excess current is due to resonant flow of quasiparticles through approximately equidistant bound centers along particular trajectories in the semiconductor interlayer. This resonant tunneling is found to be sensitive to the existence of barriers, its path depending on their height, Andreyev reflection by high barriers under a high voltage resulting in an excessive current when the resonance band is much wider than the energy gap and in a deficient current when it is much narrower. A change from excessive to deficient current is known to occur as the resistance of the sandwich is increased by an

increase of interlayer thickness or a change of its semiconductor material. The authors thank A. A. Abrikosov, L. I. Glazman, A. I. Larkin, and K. A. Matveyev for valuable discussion. References 15: 1 Russian, 4 Western.

UDC 537.312.62

### Thermodynamics of Current States in Superconductors

18620048b Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 1 Feb 88) pp 2594-2605

[Article by Ye. K. Kudinov, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] A thermodynamical scheme of current states in superconductors without an external magnetic field is constructed theoretically on a purely phenomenological basis. Formulation of the first principle of thermodynamics for equilibrium of a current state are followed by application of this scheme to the Landau-Ginzburg theory and formal determination of the equilibrium function  $F(T, k)$  according to that theory. As special cases are considered the London limit, a thin film with either the phase variable  $k$  or the current variable  $I$  given, and two thin films with a weak link. The static Josephson effect is completely describable within the framework of this thermodynamical scheme, dynamic fluctuations of the phase variable in a current state occurring in the form of an electric field observable at instability points and its static fluctuations not occurring in the physical sense. The scheme, with appropriate modifications, is also applicable to superfluidity. The author thanks V. V. Bryskin, S. N. Dorogovtsev, S. A. Ktitorov, S. T. Pavlov, Yu. A. Firsov, and G. Yu. Yashin for helpful discussions, contact with the late Yu. N. Obratsov having played a decisive role in the author's development of this thermodynamical scheme. Figures 5; references 8: 5 Russian, 3 Western (2 in Russian translation).

UDC 538.22+537.312.62

### Shielding of Electromagnetic Interactions in Superconductors

18620048c Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 15 Mar 88) pp 2683-2687

[Article by A. A. Matsutsin, Minsk State Institute of Medicine]

[Abstract] Shielding of electromagnetic interactions in bulk superconductors by the compensation mechanism involving Meissner currents is analyzed on the basis of the applicable Maxwell equation and using the London gauge for the magnetic vector-potential, in accordance with the model of localized magnetic and spin moments. The general relations are applied to the two limiting

superconductor types, a London superconductor with a field penetration depth much larger than the electron coherence length and a Pippard superconductor with a field penetration depth much smaller than the electron coherence length with the distance between spin moments either much smaller or much larger than the electron coherence length in each case. Calculations reveal that the energy of electromagnetic interactions decreases upon superconducting transition and that the shielding effect is similar in both superconductors, only starts at a much shorter distance in a London superconductor than in a Pippard superconductor but in both becomes stronger as the temperature drops. The author thanks L.N. Bulayevskiy for suggesting the topic and assisting in the tackling of it. Figures 2; references 8: 2 Russian, 6 Western.

UDC 537.312.62

### Distribution of Oxygen Ions in Superconductor Ceramic

18620048d Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 18 Mar 88) pp 2688-2691

[Article by A. M. Khasanov, S. S. Tsarevskiy, and A. B. Liberman, Kazan State University imeni V. I. Ulyanov-Lenin]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_{2.97}\text{Fe}_{0.03}\text{O}_x$  ceramic was made which involved Moessbauer spectroscopy and revealed something about the distribution of oxygen ions in it, replacement of a small fraction of Cu with Fe not having noticeably shifted the critical superconducting transition temperature from the 92 K for  $\text{YBa}_2\text{Cu}_3\text{O}_x$  ceramic synthesized by a standard method. Moessbauer spectra of  $^{57}\text{Fe}$  nuclei were recorded over the 300-80 K temperature range after synthesis of the ceramic, after subsequent quenching from 800 deg C in air, and after subsequent annealing at 800 deg C in an oxygen atmosphere, so that the effect of attendant phase transitions could be monitored. The isomeric shifts and the quadrupole splits indicate trivalent Fe ions replacing Cu1 and Cu2, no noticeable change in the quadrupole splits upon a temperature drop from 300 K to 80 K indicating a lattice gradient of the electric field on  $^{57}\text{Fe}$  nuclei. The relative intensities of the spectral components corresponding to Fe1, Fe2, Fe4 doublets in Cu1 positions correlate closely with the configuration of oxygen vacancies in ceramic with oxygen deficiency, doublets F3 and F5 being in Cu2 positions. Two possible distributions of oxygen ions in the Cu1 plane can be inferred from these data: either an ordered one in Cu-O chains along the b-axis or a disordered one in the (ab) plane. The relative intensities of Fe1 and Fe2 doublets correlate closely with an ordered distribution in  $\text{YBa}_2\text{Cu}_3\text{O}_{6.85}$  ceramic. Figures 2; references 7: 1 Russian, 6 Western.



UDC 537.312.62

**Effect of Equilibrium Phase Composition on Superconductivity of Materials in  $Y_2O_3$ -BaO-CuO System**

18620048e Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 13 Apr 88) pp 2800-2804

[Article by Yu. Ya. Skolis, G. A. Chesnokov, S. F. Pashin, S. V. Kutsenko, M. L. Kovba, V. V. Moshchalkov, I. G. Muttik, and N. A. Samarin, Moscow State University imeni M. V. Lomonosov]

[Abstract] An experimental study of superconductor materials  $Y_2O_3$ -BaO-CuO system was made for a determination, by the method of x-ray phase analysis, the effect of their phase composition on the temperature dependence of their electrical resistivity and on their critical superconducting transition temperature. Specimens of 20 different materials were produced by mixing 99.9 pct pure  $Y_2O_3$ , analytically pure  $BaCO_3$ , and extra-pure CuO in various proportions, including two mixtures of  $BaCO_3$ , and extra-pure CuO in various proportions, including two mixtures of  $BaCO_3$  and CuO without  $Y_2O_3$  and two mixtures of  $Y_2O_3$  and CuO without  $BaCO_3$ . Each ingredient had been preheated at 900 deg C in air for 40-50 h and especially so CuO, to ensure complete absence of  $Cu_2O$  impurity. Precisely weighed batches of each ingredient were ground and mixed in an agate crucible with ether, acetone, or ethanol. The mixtures were compacted into pellets under a pressure of approximately 2000 kgf/cm<sup>2</sup> and then heat treated in corundum crucibles under room pressure in several runs, the 50 h first run at 800 deg C being followed by several 50-70 h runs at 900 deg C, with quenching in an air stream (cooling rate 40-50 deg/s to 600 deg C and 10-20 deg/s to room temperature) followed by grinding and recompaction after each run. This treatment was repeated until an equilibrium composition in accordance with the Gibbs phase rule had been reached, usually after 150-200 h of heat treatment of 900 deg C. Phase analysis was done by roentgenography with a Guignet camera and a  $CuK_{\alpha}$ -radiation source. The electrical resistance at temperatures covering the 300-4.2 K range was measured by the standard current-voltage method with direct current in an automatic test stand with a "NORD-10S" minicomputer and an Elektronika NTs-80 microcomputer, the temperature being recorded with a Cu/Cu-Fe thermocouple. On the basis of the data have been identified two quasi-binary compounds  $BaCuO_2$  (cubic),  $Y_2Cu_2O_5$  (rhombic) and two quasi-ternary compounds  $Y_2BaCuO_5$  (rhombic),  $YBa_2Cu_3O_{6.5+e}$  (rhombic) on the 900 deg C isothermal  $YO_{1.5}$ -BaO-CuO(+ 1/2eO<sub>2</sub>) constitution diagram. The critical temperature was found to be approximately the same for all compounds, phase equilibrium indicating a nearly exact stoichiometry of cations in  $YBa_2Cu_3O_{6.5+e}$  and the critical temperature becoming slightly higher with a decrease of the Ba content. Figures 2; tables 3; references 10: 1 Russian, 9 Western.

UDC 537.312.62

**Response of Valence Electrons in  $Nb_3Ge$  Superconductor to Ion Displacements**

18620048f Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 9 Nov 87) pp 2831-2833

[Article by S. V. Stolbov and M. N. Rabinovich, Scientific Research Institute of Physics, Rostov-na-Donu State University]

[Abstract] The hypothesis that formation of Cooper pairs in metals depends largely on the response of electrons to ion displacements is verified for the  $Nb_3Ge$  superconductor, a representative A15 compound of transition metals with delocalized deeper below the Fermi surface d-state of valence electrons. Calculation of the scattering T-matrix in the muffin-tin approximation of the "node number—orbital moment" representation of a  $Nb_3Ge$  fragment consisting of 49 atoms with the center in one of the Nb atoms has revealed that the principal response of valence electrons to ion displacements comes here from the deeper d-states of Nb electrons and that this response is linear as long as the ion displacements do not exceed 4 pct of the 0.1560 nm large lattice  $\alpha$ -parameter. The shortest distance between Nb atoms being extraordinarily small here, electron-electron interactions cause localization of the d $\delta$  states their electrons oriented toward neighboring atoms and drive these states to the Fermi surface so that the d $\tau$  states of their electrons remain the most delocalized ones. Meanwhile, displacements of Nb ions do not cause delocalization of electron states so that a polaron effect is unlikely here owing to the strong shielding of lattice polarization by valence electrons. The authors thank Ye.G. Maksimov for helpful discussion. Figures 3; references 12: 5 Russian, 7 Western (1 in Russian translation).

UDC 538.1.339.213

**Moessbauer Spectroscopy of  $(Y,Eu)Ba_2Cu_3O$**

18620048g Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 14 Dec 87) pp 2836-2838

[Article by A. M. Khasanov, S. S. Tsarevskiy, and A. B. Liberman, Kazan State University imeni V. I. Ulyanov-Lenin]

[Abstract] An experimental study of  $YBa_2Cu_3O_{7-d}$  superconductors with the critical temperature of superconducting transition about 92 K was made involving Moessbauer spectroscopy over the 300-80 K temperature range, for the purpose of which either Y had been completely replaced with <sup>151</sup>Eu ions or Cu had been partially replaced with <sup>57</sup>Fe ions ( $YBa_2Cu_{2.97}Fe_{0.03}O_{7-d}$ ) or with <sup>119</sup>Sn ions ( $YBa_2Cu_{2.95}Sn_{0.05}O_{7-d}$ ). While structural analysis by the x-ray diffraction method revealed a single rhombic phase of all compounds with partially replaced Cu, the magnitude of the isomeric shift in the

Moessbauer spectrum of  $\text{EuBa}_2\text{Cu}_3\text{O}_{7-d}$  indicated a trivalent Eu. No noticeable changes occurred in the Moessbauer spectra as the temperature was dropped from 300 K to 80 K. Therefore, Moessbauer spectra were also recorded during various stages of the sintering process and after subsequent quenching from 800 deg C. Those of  $\text{YBa}_2\text{Cu}_{2.97}\text{Fe}_{0.03}\text{O}_{7-d}$  indicate that Fe ions, with appreciable quadrupole split, locate themselves unequally in Cu1 and Cu2 positions but, according to the magnitude of the isomeric shift, retain their 3plus valence. Those of  $\text{YBa}_2\text{Cu}_{2.95}\text{Sn}_{0.05}\text{O}_{7-d}$  indicate that Sn ions, without noticeable quadrupole split, occupy positions of either Ba or Y ions and, according to the magnitude of the isomeric shift, retain their nearly 4plus valence. Figures 1; tables 1; references 3: Western.

UDC 539.292

### Electron Tunneling Into Nonhomogeneous Superconductors

18620048h Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 9, Sep 88 (manuscript received 15 Mar 88) pp 2845-2847

[Article by M. A. Belogolovskiy and A. I. Dyachenko, Donetsk Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] Electron tunneling into a nonhomogeneous superconductor  $\text{N/S}_1$  (N-thin normal film) from an injecting superconductor  $\text{S}_2$  through an insulator I is analyzed, an  $\text{S}_2$ -I- $\text{N/S}_1$  multilayer structure with a low-transmittance barrier being suitable for experimental verification. The tunneling current-voltage characteristic, describable as a double integral with respect to tunneling energy and angle-dependent tunneling probability, is evaluated for calculation of the energy gap  $\text{D}_1$  of superconductor  $\text{S}_1$  and the differential conductivity of the junction. The latter is found to have two similar singularities, a strong one independent of the temperature when the applied voltage is equal to  $\text{E}_0 + \text{D}_2$  ( $\text{E}_0$ - energy of bound state within potential well in N-film,  $\text{D}_2$ - energy gap of superconductor  $\text{S}_2$ ) and a weak one which vanishes as zero absolute temperature is approached when the applied voltage is equal to  $\text{E}_0$  minus  $\text{D}_2$  (assuming that  $\text{D}_2$  is smaller than  $\text{E}_0$ ). When the applied voltage becomes equal to  $\text{D}_1$  plus  $\text{D}_2$  and to  $\text{D}_1$  minus  $\text{D}_2$ , the differential conductivity of the junction respectively increases and decreases by steps of different magnitudes. The authors thank V. M. Svistunov for suggesting this topic as well as for analysis and discussion of the results. Figures 1; references 3: Western.

UDC 539.2:539.292

### Study of $\text{U}_2\text{PtC}_2$ Heavy-Fermion Superconductor With Use of Microjunctions

18620046b Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 8, Aug 88 (manuscript received 16 Feb 88) pp 2328-2338

[Article by Yu. G. Naydok, I. K. Yanson, P. N. Chubov, V. M. Kirzhner, G. Kh. Panova, and Z. M. Alekseyeva, Institute of Low-Temperature Engineering Physics]

[Abstract] An experimental study of the  $\text{U}_2\text{PtC}_2$  heavy-fermion superconductor was made by microjunction

spectroscopy of this material, specimens of it having been produced by fusion of UC and Pt in an electric-arc furnace with a nonconsumable tungsten electrode on a copper tray in an argon atmosphere and then annealed at a temperature of 1400 K for 3 h. Electrical resistance measurements for a determination of its temperature dependence over the 300-1.3 K range were made by the current-voltage method with a current of 1 A and with a voltage comparator, the temperature being measured with an Allen-Bradley resistance thermometer. The differential resistance  $\text{R}_d$  of  $\text{U}_2\text{PtC}_2/\text{metal}$  (Cu, Mo, Ag, Ta, W) and  $\text{U}_2\text{PtC}_2/\text{U}_2\text{PtC}_2$  junctions,  $\text{R}_d$  being the first derivative of voltage with respect to current  $\text{dV/dI}$ , its voltage dependence over the -30-(30) mV range and that of the second derivative  $\text{d}^2\text{V/dI}^2$  over the -75-(75) mV range were determined at various temperatures. The derivative of resistance with respect to temperature  $\text{dR/dT}$  was determined from the temperature of the differential resistance at zero voltage. The data are analyzed and interpreted on the basis of the Bardeen-Cooper-Schrieffer theory. Heating of the "shorts" by the transport current is evidently responsible for the nonlinearity of the current-voltage characteristics, singularities at voltages below 2 mV and temperatures below the critical 1.5 K determining the magnitude and the temperature dependence of the energy gap. Figures 7; tables 3; references 17: 6 Russian, 11 Western.

UDC 539.2.92

### Critical Parameters of $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$ Superconductor

18620046c Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 8, Aug 88 (manuscript received 15 Mar 88) pp 2432-22436

[Article by Ya. V. Kopelevich, V. V. Lemanov, E. B. Sonin, and P. P. Syrnikov, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of the  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  superconductor ceramic was made for a determination of not only its electrical characteristics including the temperature dependence of the resistance increment over the 4.2-273 K range but also of the critical magnetic fields and the thickness dependence of the critical current. Specimens were produced according to the standard technology, but with  $\text{Ba}(\text{NO}_3)_2$  instead of  $\text{BaCO}_3$  for sintering at 750-800 deg C rather than at 600 deg C. They were compacted under a pressure of 2 kbars into up to 5 mm thick disks 10-15 mm in diameter. These were annealed, some only in air at 900 deg C for 12 h and others then also in an oxygen stream at 950 deg C for 24 h. Their final density was 5.8  $\text{g/cm}^3$  and thus 10 pct lower than according to x-ray measurements, their mean grain size being 0.010 mm. They consisted of a single phase with not more than 5 pct impurity and with a characteristically negative temperature coefficient of resistivity equal to approximately  $0.002 \text{ K}^{-1}$ . The temperature range of superconducting transition was 3 K

wide at a current of 0.1 mA and 4 K wide at a current of 10 mA for specimens annealed in oxygen, 10 K wide at current of 0.1 mA and 40 K wide at a current of 10 mA for specimens also annealed in air only. The dependence of the voltage drop on the magnetic field intensity and the current-voltage characteristic, measured over the 0-2.2 kOe range at 77 K, reveal a weak lower critical magnetic field of 400 Oe intensity and indicate a strong pinning of vortices in weak-link structures in weak magnetic fields only slightly stronger than the critical. Extrapolation of the linear field dependence of the voltage drop yields an upper critical magnetic field of approximately 150 kOe intensity. The low critical current indicates a weak-link structure and a fairly uniform supercurrent distribution over the volume. The authors thank A. M. Dyakonov for assisting in measurements and N. V. Zaytsev for performing x-ray phase analyses. Figures 3; references 8: 2 Russian, 6 Western (3 in Russian translation).

UDC 537.312.62

# **Magnetic Structure of Anisotropic Type-II Superconductors**

18620046d Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 8, Aug 88 (manuscript received 10 Feb 88) pp 2512-2513

[Article by R. G. Mints, Institute of High Temperatures, USSR Academy of Sciences, Moscow]

[Abstract] The magnetic structure of anisotropic type-II superconductors is analyzed theoretically on the basis of the London equation for a uniaxial superconductor. Calculations for an ellipsoid of revolution reveal that the magnetic moment increases not only as the intensity of the external magnetic field is creased up to the lower critical  $H_{c1}$ , as in the case of isotropic superconductors, but also as it is further increased up to the upper critical  $H_{c2}$ , the latter being lower than  $H_{c1}k \cdot \tan A$  ( $k$  - anisotropy index,  $A$  - angle between external magnetic field and superconductor axis of symmetry). The author thanks A. V. Gurevich and Ye.I. Kats for helpful discussions. References 3: 1 Russian, 2 Western.

UDC 537.312.62

# **Effect of Exposure of Nitrogen Vapor on Critical Superconducting Transition Temperature for $YBa_2Cu_3O_{7-d}$ High-Temperature Superconductor**

18620046e Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 8, Aug 88 (manuscript received 17 Feb 88) pp 2520-2523

[Article by A. I. Golovashkin, I. S. Levchenko, G. P. Motulevich, and L. M. Polukhina, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of the  $YBa_2Cu_3O_{7-d}$  high-temperature super-conductor was made, for the

purpose of determining the effect of its exposure to  $N_2$ -vapor on the critical superconducting transition temperature. Two specimens were produced from the same mixture of  $Y_2O_3$ ,  $BaCO_3$ ,  $CuO$  powders with grains in the micron size fracture and annealed, after sintering and compaction, in an oxygen atmosphere. Their density was 3.8 g/cm<sup>3</sup> and their electrical resistance was 2 times higher at room temperature than just before superconducting transition. The temperature dependence of their electrical resistance was measured by the standard current-voltage method with a current of 5-10 mA, the slope of the  $R(T)$  curve being then plotted over the 91-98 K range for a more precise monitoring of the critical temperature. The results indicate that heating in  $N_2$ -vapor at temperatures above 155 K up to 200 K somewhat raises the critical temperature and heating in  $N_2$ -vapor at temperatures below 155 K somewhat lowers it, the change being smaller for the specimen stored in air than for the specimen stored hermetically without  $CO_2$  and water vapor in the container. They also reveal a hysteresis, approximately twice as large for the air-stored specimen with a large surface than for the hermetically stored one with a small surface but much more likely owing to entrapped magnetic flux than due to overheating and overcooling. The hermetically stored specimen exhibited an additional anomaly, a second rise of its electrical resistance upon rise of the temperature above 165K, indicating structural transformation such as ordering of oxygen vacancies beginning at the 155 K critical temperature. These effects are attributed to formation of an anomalous oxygen vacancy structure and implantation of nitrogen atoms in the lattice during heating in  $N$ -vapor above 155 K. The authors thank K. V. Mitsen for preparation of the specimens. Figures 2; references 3: 2 Russian, 1 Western.

# **Crystalline Structure of $LaBa_2Cu_3O_7$ Superconductor Compound**

18620009c Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 7, Jul 88 (manuscript received 19 Jan 88) pp 298-300

[Article by V. P. Glazkov, I. P. Zibrov, A. V. Irodova, V. A. Somenkov, S. M. Stishov, A. Ya. Shapiro, and S. Sh. Milshteyn, Institute of Atomic Energy imeni I. V. Kurchatov, and Institute of Crystallography, USSR Academy of Sciences]

[Abstract] An experimental study of the  $LaBa_2Cu_3O_7$  superconductor compound was made involving microstructural examination by the two methods of x-ray and neutron diffraction. A specimen of  $LaBa_2Cu_3O_7$  powder was produced from a stoichiometric mixture of  $La_2O_3$ ,  $BaCO_3$ ,  $CUO$  powders by annealing at a temperature of 1223 K in air for 24 h, with intermediate grating after 12 h. The oxygen content in the raw powder mixture and in the synthesized powder at room temperature was  $O_{6.5}$ , according to thermogravimetric analysis with a Q-1500D derivatograph. Sintering this powder, after compaction, at the same 1223 K temperature in an oxygen

atmosphere for 10 h and then cooling it to room temperature at a rate of approximately 100 K/h produced a ceramic with a critical superconducting transition temperature of 67 K, the transition range being 20 K wide. Microstructural examination was done at room temperature in a DRON-3.0 x-ray diffractometer with a  $\text{CuK}_{\alpha 1}$ - $\alpha$ -radiation source and in a DISK neutron diffractometer at the 173 nm wavelength, as reference serving the rhombic phase of  $\text{YBa}_2\text{Cu}_3\text{O}_7$  with completely disordered O4 and O5 atoms so that the symmetry of the atomic configuration became tetragonal. The minimum R-factor calculated from the integral intensities of neutron diffraction peaks was nearly equal to the 4.4 percent based on direct determination in experiment with  $\text{LaBaCuO}_{6.9-7.1}$ . Both rhombic and tetragonal phases were found to be superconducting, but only with the oxygen content within this close range about O<sub>7</sub>. The subsequently determined temperature dependence of the oxygen content in  $\text{LaBa}_2\text{Cu}_3\text{O}_{7-d}$  reveals that heating to and quenching from 100 K or higher temperature causes loss of oxygen and superconductivity, the ceramic becoming a semiconductor. The authors thank G. V. Laskova and V. P. Somenkova for assisting in x-ray experiments. Figures 2; tables 1; references 11: 4 Russian, 7 Western.

**Raman Scattering of Light in Monophase  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  Ceramic**

18620045d Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 13, 12 Jul 88 (manuscript received  
14 Apr 88) pp 1235-1238

[Article by M. F. Limonov, Yu. F. Markov, E. Pollert, and A. Triska, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_{6.63}$  ceramic was made in which its Raman spectra were recorded, specimens of this material having been produced by sintering a mixture of  $\text{Y}_2\text{O}_3$ ,  $\text{CuO}$ ,  $\text{BaCO}_3$  powders at a temperature of 1220 K in an oxygen atmosphere. Their superconducting transition was characterized by a critical temperature of 92 K and a less than 1 K wide temperature range, transition from the  $D_{4h}$  tetragonal phase to the  $D_{2h}$  rhombic phase having occurred within the 890-830 K range. Following the x-ray analysis, their Raman spectra were recorded over the 10-1000  $\text{cm}^{-1}$  range and analyzed in a "Dilor-24" triple spectrometer with a "spectra Physics" 300 mW Ar-laser. Measurements were made in the backscattering configuration at a temperature of 300 K, with a rough ceramic chip surface and a highly polished surface serving as reflectors. The low intensity of Raman scattering required multiple scanning of the spectrum. It revealed a homogeneous composition of this ceramic, without "parasitic" phases such as green  $\text{Y}_2\text{BaCuO}_5$ , which was confirmed by examination under a microscope. The authors thank A.A. Kaplyanskiy for discussion. Figures 1; references 7: 2 Russian, 5 Western.

UDC 621.384.8

**Design of Superconducting Magnet System for Production of Nonuniform Magnetic Field Inside Analyzer of Static Mass-Spectrometer**  
18620034b Leningrad ZHURNAL TEKHNICHESKOY  
FIZIKI in Russian Vol 58 No 7, Jul 88 (manuscript  
received 15 May 87) pp 1432-1436

[Article by A. S. Berdnikov, S. A. Vinogradova, L. N. Gall, and S. Ya. Tipisev, Scientific-Technical Association 'Institute of Analytical Instrument Design', USSR Academy of Sciences, Leningrad]

[Abstract] A method of designing a magnet system for a static high-resolution high-sensitivity mass-spectrometer is outlined, such an instrument operating on the basis of nuclear-magnetic or ion-cyclotron resonance for analysis of ultra-heavy molecules requiring a very strong nonuniform magnetic field most readily producible by superconducting solenoids. The design of these solenoids is based on the classical Biot-Savart law and requires solution of the inverse problem for the appropriate boundary conditions, namely determining the form of coils and the current distribution in them which will yield the necessary configuration of the magnetic field inside the analyzer. The algorithm of design calculations, which has been programmed in FORTRAN, includes the QUANC subroutine of numerical integration and the SVD subroutine of expansion in singular numbers of the matrix which optimize the currents in terms of minimum r.m.s. deviation of the resulting magnetic field from the required configuration. The results are demonstrated on a pair of identical and symmetrically coaxial solenoids consisting of five non-identical segments each and producing a prismatic magnetic field with a taper all around. An experimental set of such solenoids was wound and tested with satisfactory results. Figures 3; references 9: 4 Russian, 5 Western (3 in Russian translation).

UDC 537.312.62

**Structural Instability of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  High-Temperature Superconductor at Low Temperatures**

18620031b Leningrad FIZIKA TVERDOGO TELA in  
Russian Vol 30 No 7, Jul 88 (manuscript received  
8 Feb 88) pp 2052-2057

[Article by O. V. Aleksandrov, O. M. Ivanenko, V.R. Karasik, K. V. Kiseleva, K. V. Mitsen, and O. Ye. Omelyanovskiy, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  superconductor ceramics with varying initial oxygen vacancy concentration and thus varying magnitude of the lattice c-parameter was made concerning their structural transformations at temperatures below 300 K. Polycrystalline bulk and powder specimens containing less than 2-3

percent impurity phase, their superconducting transition at 94-93 K occurring within a 1 K wide temperature range, were examined in a DRON-2.0 x-ray diffractometer with a  $\text{CuK}_{\alpha}$ -radiation source. The results indicate that the temperature dependence of the interplanar distance  $d_{1,0,10}$  becomes anomalous within two temperature ranges, changing slope within 170-160 K and dipping softly within 110-100 K. The Coefficient of linear thermal expansion, its temperature dependence obtained by differentiating the temperature dependence of  $d_{1,0,10}$ , correspondingly jumps at some temperature within 170-160 K and passes through an instability within 110-100 K. The magnitude of that instability does not correlate with redistribution of oxygen vacancies and change in their concentration, ordering of the oxygen sublattice most likely occurring within 170-160 K, but rather indicates transition to a noncommensurate phase. Figures 4; tables 1; reference 15: 7 Russian, 8 Western (1 in Russian translation).

UDC 536.42:537.226.33

**Nucleation of Low-Temperature  $D_{4h}$ -Phase on Dislocations in  $\text{SrTiO}_3$  Surface Layer**

18620031c Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 9 Feb 88) pp 2066-2070

[Article by Ye. V. Balasheva, V. V. Lemanov, S. S. Rubimov, L. M. Sorokin, and A. B. Sherman, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of  $\text{SrTiO}_3$  crystals was made, for the purpose of monitoring the  $O_h$ -to- $D_{4h}$  phase transition in the surface layer and determining the role of dislocations in this process, the surface layer known to have a higher dislocation density and different elasticity characteristics than the crystal bulk within a temperature range somewhat above the 105 K phase transition point. Three specimens cut from Verneuil crystals received a different surface treatment each: I) chemomechanical polish, II) "soft" mechanical polish with diamond powder, III) "hard" mechanical polish with diamond powder. They were examined under a JEM-7A transmission electron microscope with a 100 kV accelerating voltage and tested acoustically at temperatures covering the 105-120 K range. Sounding was done simultaneously with 114 MHz surface acoustic waves generated by an interdigital piezoceramic transducer and 110 MHz volume acoustic waves generated by a  $\text{LiNbO}_3$  transducer, longitudinal and shear waves being involved. The temperature dependence of their velocity and attenuation indicates that the  $D_{4h}$ -phase begins to form at a higher temperature in the surface layer than in the crystal bulk. The agreement of experimental data with theoretical ones based on the dislocation mechanism of  $D_{4h}$ -phase nucleation and its contribution to the acoustic anomaly near phase transitions of the second kind is closest when assuming a relaxation time of  $9 \cdot 10^{-13}$  s for the order parameter at 210 K and dislocation densities of  $10^9$

$\text{cm}^{-2}$ ,  $1.2 \cdot 10^{11} \text{ cm}^{-2}$  in specimens I), II), III) respectively. Figures 3; references 10: 5 Russian, 5 Western.

UDC 537.312.62:538.945

**Spatial Distribution of Magnetic Induction in Superconducting Ceramic**

18620031d Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 22 Feb 88) pp 2148-2151

[Article by V. M. Dzugutov and L. M. Fisher, All-Union of Institute of Electrical Engineering imeni V. I. Lenin, Moscow]

[Abstract] In an experimental study of a Y-Ba-Cu-O ceramic with a 1 K wide temperature range of superconducting transition the magnetization curves of two coaxially aligned 16 mm long cylinders 9 mm in diameter, one solid and one hollow, in a longitudinal magnetic field were measured with a vibration magnetometer and the radial profiles of magnetic induction in them were measured with a miniature 0.180 mm thick and 0.050 mm square Hall probe moving through the narrow gap between the cylinders. Measurements were made at two temperatures, 4.2 K and 77 K, the hollow cylinder having been cooled without a magnetic field. They revealed identical patterns at both temperatures and confirmed the known theory of superconducting ceramics: highly nonuniform profiles of critical current density and magnetic induction, the latter decreasing steeply beyond the field penetration depth toward the center. Figures 3; references 4: 2 Russian, 2 Western (1 in Russian translation).

UDC 541.44+539.893

**Superconducting Nb-Rh-H Phases With Atomic Hydrogen-to-Metal Ratios Up to 2**

18620031e Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 24 Feb 88) 2152-2158

[Article by V. Ye. Antonov, T. Ye. Antonova, I. T. Belash, O. V. Zharikov, A. V. Palnichenko, Ye. G. Ponyatovskiy, and V. I. Rashchupkin, Institute of Solid-State Physics, USSR Academy of Sciences, Chernogolovka (Moscow Oblast)]

[Abstract] An experimental study of Nb-Rh alloys was made concerning the effect of hydrogen impregnation, the solubility of Rh in  $\alpha$ -Nb with a B.c.c. crystal lattice reaching 14 atom.pct at temperatures not higher than 1200 deg C. Eight intermediate phases are known to form within this range, all superconducting and seven of them stable under normal conditions. Three alloys were studied:  $\text{Nb}_{88}\text{Rh}_{12}$  (b.c.c. phase),  $\text{Nb}_{75}\text{Rh}_{25}$  (A15 beta-W phase),  $\text{Nb}_{65}\text{Rh}_{35}$  ( $D8_b$  sigma-phase). Polycrystalline ingots of each were produced from zone-refined niobium with an electrical resistivity approximately 500 times higher at 300 K than at 4.2 K and 99.96 pct pure

rhodium, by smelting in suspension in an argon atmosphere in an induction furnace. They were annealed at 110 deg C for 24 h under vacuum and then cooled in the furnace. Specimens cut from these ingots, 0.3 mm thick and 3 mm square, were impregnated with molecular hydrogen at 325 deg C for 24 h and then fast cooled to -180 deg C, all under constant pressure. The pressure was raised up to 70 kbar so that the atomic hydrogen-to-metal ratio increased up to 2. Subsequent structural examinations and phase analyses were done at a 100 K temperature in a DRON-2.0 x-ray diffractometer with a  $\text{CuK}_{\alpha}$  radiation source, the lattice parameters  $a$  and  $c$  as well as the specific volume increment being thus determined after each increase of  $\text{H}_2$ -concentration. The critical superconducting transition temperature was recorded by the induction method with an a.c. bridge and was found to become lower for each alloy as the  $\text{H}_2$ -concentration increased, while the  $c/a$  ratio remained almost constant. In addition, an f.c.t. phase of the  $\text{Nb}_{88}\text{Rh}_{12}$  alloy with a slightly higher critical temperature of 0.9 K was found to form as the  $\text{H}_2$ -concentration reached the 1.7-2 range. A separate experiment was performed with Nb dihydride and V dihydride, the results confirming that both do not become superconducting at temperatures down to 0.35 K. The authors thank V. G. Glebovskiy for making his laboratory available for producing the Nb-Rh alloys and I. M. Romanenko for their chemical analysis. Figures 4; tables 1; references 19: 8 Russian, 11 Western.

UDC 535.611

#### Superconductor Characteristics of New Si-Ag Telluride Glass Under High Pressures

18620031f Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 2 Oct 87, in final version 9 Mar 88) pp 2177-2181

[Article by A. A. Andreyev, I. V. Berman, T. Z. Kyshtaubayev, B. T. Melekh, V. I. Sidorov, and Han Cui-Yin, Moscow State University imeni M. V. Lomonosov]

[Abstract] Two recently developed telluride glasses,  $\alpha\text{-Si}_{15}\text{Ag}_{15}\text{Te}_{70}$  and  $\alpha\text{-Si}_{15}\text{Ag}_5\text{Te}_{80}$  with an Anderson dielectric-to-conductor transition under a critical pressure of about 70 kbar, were tested for the temperature dependence of their electrical resistivity over the 300-2 K range under pressures above the critical up to 200 kbar and for the pressure dependence of their electrical resistivity at 300 K over the 0-200 kbar range. Specimens of these glasses had been synthesized from ultrapure elements at 1000 deg C under vacuum in quartz flasks, with intermittent mixing over a 6-7 h period, and then quenched to 0 deg C in ice water. Their critical superconducting transition temperature was also recorded, for a determination of its pressure dependence proving to be a nonmonotonic one. The highest critical temperature for  $\alpha\text{-Si}_{15}\text{Ag}_{15}\text{Te}_{70}$  and  $\alpha\text{-Si}_{15}\text{Ag}_5\text{Te}_{80}$  was found to be 6.4 K under a pressure of 130 kbar and almost 5 K under a pressure of 120 kbar

respectively. The superconducting transition of  $\alpha\text{-Si}_{15}\text{Ag}_{15}\text{Te}_{70}$  under pressure below 100 kbar was found to proceed in two steps, the upper critical temperature of 5.6 K being almost independent of the pressure and the lower one decreasing to below 1.5 K with decreasing pressure. The temperature dependence of the upper critical magnetic field below the critical temperature was measured under pressures above the critical and found to be almost linear rather than parabolic according to the theory of "dirty" superconductors, the upper critical magnetic field intensity being generally under higher pressure up to the critical one. X-ray structural examination and phase analysis were done under a pressure of 100 kbar. The authors thank N. A. Khatanov for x-ray measurements. Figures 4; references 10: 2 Russian, 8 Western.

UDC 539.2

#### Effect of Weak Electron Localization and of Electron-Electron Interaction in Amorphous Bismuth Films on Temperature Dependence of Their Electrical Conductivity

18620031g Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 5 Jan 88, in final version 11 Mar 88) pp 2182-2187

[Article by B. I. Belevtsev, Yu. F. Komnik, and A. V. Fomin, Institute of Low-Temperature Physics, UkSSR Academy of Sciences, Kharkov]

[Abstract] An experimental study of amorphous bismuth was made concerning the influence of weak electron localization and of electron-electron interaction in films of this bismuth modification on the temperature dependence of their electrical conductivity, this modification being a metastable superconducting one produced by condensation at low temperatures and forming films which build up to smaller thickness as the temperature is raised so that above 60 K they cannot exist at all. Accordingly, 2-10 nm thick films were vacuum-deposited at rates of 0.05-0.1 nm/s on single-crystal sapphire wafers at a temperature of 1.5-2 K. They were annealed at temperatures of 30-60 K, whereupon their electrical surface resistance was measured at temperatures covering the 60-4.2 K range and the magnetoresistance was measured in a transverse magnetic field of up to 43 KOe intensity. Their electrical resistance was found to peak within 11-9 K, the temperature range of superconducting transitions, to decrease steeply with dropping temperature and to decrease slower nonlinearly with rising temperature before continuing to decrease linearly above 20 K. The results are evaluated and analyzed on the basis of various known theoretical models, taking into account the electron diffusion coefficient and the electron phase relaxation time in inelastic processes such as electron-phonon collisions. Figures 3; references 19: 5 Russian, 14 Western (1 in Russian translation).

UDC 537.312.62

**Possible Mechanism of High-Temperature Superconductivity (Critical Temperature Above 150 K) in Some Specimens of Y-Ba-Cu-O Ceramics**

18620031h Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 9 Feb 88) pp 2221-2223

[Article by M. V. Krasinkova and B. Ya. Moyzhes, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] A few specimens of Y-Ba-Cu-O ceramics with superconducting transition within the 155-200 K temperature range and even above 300 K have been produced in various laboratories, with a small or no Meissner effect, this anomaly indicating a surface rather than volume superconductivity and possibly contact of the regular superconducting phase with some other superconducting one. This other phase could be CuO, an antiferromagnetic material with a Neel point at 230 K stimulating surface superconductivity, a stoichiometric excess of the CuO oxide known to be sometimes added to the powder mixture for improvement of the sintering process but this phase not being thermodynamically stable and, therefore, most often not retainable. References 25: 4 Russian, 21 Western (1 in Russian translation).

UDC 538.248:537.312.62

**Characteristics of Magnetic Flux Entrapment in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  High-Temperature Superconductors in Weak Magnetic Field**

18620031i Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 7, Jul 88 (manuscript received 28 May 88) pp 2249-2251

[Article by Ye. V. Blinov, P. P. Kuleshov, M. G. Semenchenko, Yu. P. Stepanov, and V. G. Fleysher, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of a  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  superconductor single crystal in a weak magnetic field was made concerning its entrapment of magnetic flux during cooling. It was cooled to below the critical temperature without a magnetic field and in a weak magnetic field normal to its surface. The intensity of the magnetizing field was varied over the 0.5-240 Oe range and the magnetization was measured with a quantum magnetometer, the latter shielded from the external magnetic field of the magnetizing solenoid and atoms being oriented optically. The solenoid produced a magnetic induction of 0.08 G, the variance of the residual not exceeding  $10^{-6}$  G. Measurements were made twice, the second time with the crystal orientation reversed by rotation through 180 deg, so as to separate readings of the residual magnetic flux from the contribution of

diamagnetic shielding to the recorded signal. The field dependence of the residual magnetic moment was found to follow markedly different trends after cooling without a magnetic field a residual magnetic moment was recorded only as the intensity of the magnetizing field had reached 7 Oe before the field was turned off and, following a linear increase with rising field intensity, it saturated. After cooling in a magnetic field a residual magnetic moment was recorded already upon magnetization with a field of only 0.51 Oe intensity and it saturated at the same level following a much steeper increase with increasing field intensity. These differences are attributable to a strong anisotropy of magnetic flux entrapment by a single crystal in a magnetic field, the residual magnetic flux remaining normal to the crystal surface even when the latter is oriented parallel to the magnetizing field. An interpretation in terms of the vortex theory must take into account the low lower critical magnetic field intensity at which the energy threshold for formation of vortices is reached, the maximum residual magnetic induction of 10 G based on the maximum magnetic moment corresponding to a mean vortex density of approximately  $5 \cdot 10^7 \text{ cm}^{-2}$ . The authors thank B. P. Zakharchena for discussion and S. M. Stishov for supplying the single crystal. Figures 2; references 3: 2 Russian, 1 Western (in Russian translation).

UDC (546.562+537.312.62):538.56

**Anomalous Absorption of Electromagnetic Field by  $\text{YBa}_2\text{Cu}_3\text{O}_7$  and  $\text{HoBa}_2\text{Cu}_3\text{O}_7$  Superconductor Ceramics**

18620028a Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 1, Jul 88 (manuscript received 14 Sep 87, in final version 9 Nov 87) pp 188-189

[Article by L. Ya. Kobelev, L. L. Nugayeva, Yu. F. Gorin, A. N. Babushkin, and V. B. Zlokazov, Ural State University imeni A. M. Gorkiy]

[Abstract] An experimental study of  $\text{YBa}_2\text{Cu}_3\text{O}_7$  and  $\text{HoBa}_2\text{Cu}_3\text{O}_7$  ceramics was made concerning their absorption of an electromagnetic field during their superconducting transition. Measurements were made by the standard induction method with an alternating-current bridge at frequencies of 1.5, 10, 50 kHz at temperatures covering the 300-4.2 K range. The results indicate that both upper and lower temperature limits of the superconducting transition range rise as the frequency of the electromagnetic field is raised, the upper limit only slightly throughout the given frequency range and the lower limit appreciably as the frequency of the electromagnetic field becomes higher. The dielectric loss tangent was found to peak within the superconducting transition range, the peak shifting toward the upper end of this range and becoming sharper as the frequency of the electromagnetic field was raised. Figures 2; references 1: Western.

UDC 669.85/.86'781'3'789:536.76

**Spectra of Raman Scattering of Light in R-Ba-Cu-O Superconductors**

18620028b Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 1, Jul 88 (manuscript received 12 Oct 87) pp 184-186

[Article by Yu. S. Ponosov, V. L. Kozhevnikov, O. V. Gurin, S. M. Cheshnitskiy, G. A. Bolotin, and N. K. Shindelman, Institute of Metal Physics and Institute of Chemistry, Ural Department, and Institute of Electrophysics, USSR Academy of Sciences]

[Abstract] An experimental study of R-Ba-Cu-O (R-Y,Sm,Ho) superconductor ceramics was made, for an analysis of their phonon spectra by the method of Raman spectroscopy. Specimens of monophase  $\text{RBa}_2\text{Cu}_3\text{O}_{7-d}$  ceramics and specimens of polyphase  $\text{Y}_2\text{Ba}_3\text{Cu}_7\text{O}_{14-d}$  ceramic were prepared for Raman scattering measurements, their superconducting transition occurring within 94-92 K with a narrow range of critical temperature and over a 20 K wide temperature range respectively. They were excited with light at 488 nm and 514.5 nm wavelengths. The scattering spectra of all monophase ceramics contained six bands (216, 270, 336, 440, 505, 596  $\text{cm}^{-1}$ ) at 300 K and at 75 K. The spectra of  $\text{Y}_2\text{Ba}_3\text{Cu}_7\text{O}_{14-d}$  polyphase ceramic contained also four lines (317, 390, 487, 600  $\text{cm}^{-1}$ ). Figures 2; references 8: 3 Russian, 5 Western.

UDC 669.3'387':537.312.62

**Comprehensive Study Concerning Physics and Chemistry of  $\text{LnBa}_2\text{Cu}_3\text{O}_y$  High-Temperature Superconductor Ceramics**

18620003b Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 6, Jun 88 (manuscript received 12 Dec 87) pp 50-53

[Article by V. P. Seminozhenko, corresponding member, UkrSSR Academy of Sciences, L. A. Kotok, L. A. Kvichko, T. G. Korshikova, Yu. G. Litvinenko, O. V. Meshkova, P. P. Mateychenko, Z. M. Nartova, Ye. K. Saliychuk, T. S. Teplitskaya, and N. N. Fedorova]

[Abstract] An experimental study of  $\text{LnBa}_2\text{Cu}_3\text{O}_y$  (Ln-Y,Gd,Tm,Yb) high-temperature superconductor ceramics was made, for the purpose of monitoring the mechanism of their solid-phase synthesis. Specimens were produced by sintering two stoichiometric mixtures: 1.  $\text{Ba}(\text{NO}_3)_2$ ,  $\text{Cu}(\text{NO}_3)_2$ ,  $\text{Ln}(\text{NO}_3)_3$ ; 2.  $\text{CuO}$ ,  $\text{Ln}_2\text{O}_3$ , and  $\text{BaCO}_3$ ,  $\text{BaO}$ , or  $\text{BaO}_2$ . Sintering was done in air and in an oxygen atmosphere. The process was monitored by differential thermal analysis and thermogravimetric analysis with derivatography of raw mixtures during heating at a rate of 7.5 deg/min in an MOM-1500 instrument, by dilatometry, by x-ray phase analysis, by chemical analysis, and by microanalysis with an electronic probe. The results indicate ways to optimize the synthesis in terms of process time and attainable maximum isothermal expansion. They also indicate that replacement of  $\text{BaCO}_3$  with  $\text{BaO}$  or  $\text{BaO}_2$  in mixture with  $\text{CuO}$  and  $\text{Ln}_2\text{O}_3$  does not significantly alter the product and that a mixture of nitrates can be sintered at a lower temperature for production of a pure 123-phase. The synthesis was found to be in each case a multistage process and formation of the 123-phase to be reversible, identical intermediate products appearing during synthesis and during decomposition. The results of this study have also established the temperature range within which the 123-phase can come into existence. Figures 4; tables 1; references 7: 2 Russian, 5 Western.



UDC 517

**Idempotent Analysis as Tool in Control and Optimal Synthesis Theory. I**

18620136a Moscow *FUNKTSIONALNYY ANALIZ I YEGO PRILOZHENIYA* in Russian  
Vol 23 No 1, Jan-Mar 89 (manuscript received 20 Mar 88) pp 1-14

[Article by V. N. Kolokoltsov and V. P. Maslov, Moscow Institute of Electronic Machine Building]

[Abstract] This first part of a two-part research study gives the principles for an idempotent analysis for the case of linearly ordered idempotent half-rings. A Duhamel principle is derived for general linear (in a new sense) evolutionary equations making it possible to express solutions of inhomogeneous problems through solutions of homogeneous problems and to construct a Cauchy problem theory for a Bellman nonlinear differential equation (or a Hamilton-Jacobi equation with a

convex Hamiltonian) "with constant coefficients." The second part of the study (to be published) will be devoted to the Cauchy problem for a general Bellman homogeneous differential equation. References 21: 15 Russian, 6 Western.

UDC 512.546

**Power of Open  $\sigma$ -Compact Sets in Space of Noncompact Subgroups of Topological Group**

18620097a Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 40 No 6, Nov-Dec 88 (manuscript received 8 Feb 88) pp 803-807

[Article by A. G. Piskunov, Kiev University]

[Abstract] It is demonstrated that the space of closed subgroups of a locally compact group  $G$  is  $\sigma$  compact then and only then when  $G$  is  $\sigma$  compact and contains only a countable number of noncompact subgroups. References: 8 Russian.

UDC 519.622

**Class of (m,k) Methods for Solving Stiff Systems**

18620130b Moscow *ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI* in Russian Vol 29 No 2, Feb 89 (manuscript received 29 Apr 87, after revision 24 Jun 88) pp 194-201

[Article by Ye. A. Novikov, Yu. A. Shitov and Yu. I. Shokin, Krasnoyarsk]

[Abstract] A class of (m,k)-methods is proposed for numerical solution of the Cauchy problem for stiff systems of ordinary differential equations. Schemes with one and two computations of the right-hand side are examined in detail, followed by an evaluation of the maximal order of accuracy of an L-stable scheme with two computations of the right-hand side. In each interval there is one decomposition of the Jacobi matrix, m return runs in the Gauss method and k computations of the right-hand side of the differential problem. L-stable (m,k) methods of the second and fourth orders of accuracy are constructed for  $k = 1$  and  $k = 2$  respectively. The results of computations are presented. References 14: 6 Russian, 8 Western.

UDC 517.836

**Verdier Elliptical Solitons and Weierstrass Reduction Theory**

18620136b Moscow *FUNKTSIONALNYY ANALIZ I YEGO PRILOZHENIYA* in Russian Vol 23 No 1, Jan-Mar 89 (manuscript received 18 Jan 88) pp 57-58

[Article by Ye. D. Belokolos and V. Z. Enolskiy, Physics of Metals Institute, Ukrainian Academy of Sciences]

[Abstract] J. L. Verdier ("New Elliptic Solitons," Preprint, Paris, 1987) recently discovered that in addition to Lamé g-zonal potentials there is another series of finite-zonal potentials of the Schrodinger equation expressed through elliptical functions. Extending these findings by Verdier, it is shown that similar to the Lamé potentials, the Verdier potentials can be obtained within the framework of the theory of Weierstrass reduction of Riemann theta functions and Abelian integrals to the lowest species, as was examined by the authors relative to integrable nonlinear equations in UMN, Vol 37, No 4, p 89, 1982). References 7: 4 Russian, 3 Western.

UDC 517.9

**Perturbations of Self-Adjoint Operators by Singular Bilinear Forms**

18620125a Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 41 No 1, Jan 89 (manuscript received 23 Jun 87) pp 3-19

[Article by V. D. Koshmanenko, Mathematics Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] Results of construction of a singularly perturbed operator in an abstract formulation are presented. The point of departure is an interpretation of a

singular perturbation in the form of an unclosed bilinear form not having an operator representation. The principal properties of singular bilinear forms are given and their classification is presented. A correlation is established between singular bilinear forms and abstract boundary conditions in the theory of self-adjoint expansions of symmetric positive operators. The method for constructing a singularly perturbed operator corresponding to this correlation is described in adequate detail in both initial space and in orthogonally expanded space. Rank 1 singular perturbations are examined as applications. References 29: 20 Russian, 9 Western.

UDC 517.938

**One Class of Solutions of Quasilinear Differential System With Slowly Changing Parameters**

18620125b Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 41 No 1, Jan 89 (manuscript received 22 Apr 86) pp 101-103

[Article by A. V. Kostin and S. A. Shchegolev, Odessa University; Odessa Institute of Marine Engineers]

[Abstract] Although systems of differential equations with slowly changing parameters have been examined by many authors, in the formulation used in this article the problem of investigation of such systems has never been examined. A quasilinear system of ordinary differential equations with a linear part of almost triangular form is investigated. The coefficients of the system have the form of trigonometric series with slowly changing coefficients and frequency. A study is made of the existence of a special solution having a similar structure in this system. References: 7 Russian.

UDC 519.624

**Features of Unique Solvability of Linear Boundary Value Problem for Ordinary Differential Equation**

18620102a Moscow *ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI* in Russian Vol 29 No 1, Jan 89 (manuscript received 26 Apr 88) pp 50-66

[Article by D. S. Dzhumabayev, Alma-Ata]

[Abstract] The parametrization method is used in investigating a two-point boundary value problem. An interrelationship is established between unique solvability of the considered problem and invertibility of the matrix  $Q_{\nu}(h)$ , formed from the boundary value conditions and the matrix of the differential equation. On the basis of the recurrent formulas for inversion of the  $Q_{\nu}(h)$  matrix the necessary and adequate conditions are found for unique solvability in terms of the initial data. Algorithms are proposed for finding a solution and convergence evaluations are presented. References 14: 12 Russian, 2 Western.

**Asymptotics of Cauchy Problem Solution for Landau-Lifshits Equation With  $t \rightarrow \infty$**   
18620085 Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 77 No 2, Nov 88 (manuscript received 13 Feb 87)  
pp 163-170

[Article by R. F. Bikbayev, Bashkir Affiliate, USSR Academy of Sciences]

[Abstract] The asymptotic behavior of solution of the Cauchy problem for the Landau-Lifshitz equation was investigated by the inverse problem method when  $t \rightarrow +\infty$ ,  $\xi = O(1)$  by R. F. Bikbayev, et al. in TMF, Vol 76, No 1, pp 3-17, 1978. In continuing work along these lines, the leading term in the asymptotics of the Cauchy problem solution with  $t \rightarrow +/\infty$  is found for the Landau-Lifshitz equation for the case of rapidly decreasing initial conditions. The interaction between the oscillator background solution corresponding to the continuous spectrum and soliton excitations is described. References 11: 8 Russian, 3 Western.

UDC 517.923

**Wronskians of Solutions of One Class of Differential Equations With Polynomial Coefficients**  
18620097b Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 40 No 6, Nov-Dec 88  
(manuscript received 25 Dec 85, after revision 6 Apr 87)  
pp 694-699

[Article by V. S. Adamchik and A. D. Lizarev, Belorussian University]

[Abstract] A fundamental system of solutions of the differential equation

$$\sum_{i=0}^{q+1} (a_i - b_i y^q - c_i y^{mq}) y^i d^i w / dy^i = 0.$$

was constructed. Some properties of the functions  $p_{s,q}$  through which these solutions are expressed are examined. It is shown that the Wronskians of the solutions have a different form, depending on the relations between  $p$ ,  $q$  and  $s$ . An example of use of the  $p_{s,q}$  functions and a Wronskian in the interpretation of the inhomogeneous differential equation for radial movements of a rotating disk is given. References 16: 15 Russian, 1 Western.

UDC 517.982

**Inequalities of Parallelogram in Banach Spaces and Some Properties of Dual Mapping**  
18620097c Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 40 No 6, Nov-Dec 88  
(manuscript received 13 Jan 86, after revision 5 Sep 86)  
pp 769-771

[Article by Ya. I. Alber and A. I. Notik, Radio Physics Scientific Research Institute, Gorkiy]

[Abstract] The lower and upper inequalities of the parallelogram:

$$\begin{aligned} 2 \|x\|^2 + 2 \|y\|^2 - \|x+y\|^2 &\geq \\ &\geq (p-1) \|x-y\|^2, \quad 1 < p \leq 2 \end{aligned}$$

were determined in the arbitrary Banach space  $b$ . Here  $\delta_B$  and  $\rho_B(\tau)$  are the convexity and smoothness moduli of the space  $B$ . The continuity and monotony moduli of normalized dual mapping are computed. References 6: 2 Russian, 4 Western.

UDC 517.9

**Action of Random Forces on Gyroscopic Systems**  
18620054 Kiev *UKRAINSKIY MATEMATICHESKIY ZHURNAL* in Russian Vol 40 No 5, Sep-Oct 88  
(manuscript received 31 Dec 87) pp 592-599

[Article by Yu. A. Mitropolskiy and F. U. Nosirov, Institute of Mathematics, UkSSR Academy of Sciences, Kiev]

[Abstract] The system of two stochastic differential equations with a small parameter describing action of random forces on a gyroscopic system is solved by successive approximations, after having been converted to standard form by the asymptotic Kolmogorov-Bogolyubov-Mitropolskiy method. The corresponding Kolmogorov-Fokker-Planck equation, in this case a standard parabolic one, is then averaged according to R. Z. Khasminskiy's principle for either analytical or numerical solution. An autonomous gyroscopic system is considered as a special case. References 8: Russian.

**Green's Function for Two-Particle Coulomb Interaction in Momentum Space With Explicitly Extracted Singularities**

18620053 Moscow *TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA* in Russian  
Vol 76 No 3, Sep 88 (manuscript received 18 Mar 87)  
pp 339-349

[Article by S. A. Storozhenko and S. A. Shadchin, Institute of Nuclear Research, UkSSR Academy of Sciences]

[Abstract] The problem of Coulomb scattering of two charged particles with initial and final momentum beyond the energy surface is considered and a new analytical expression for the corresponding Green's function in the momentum space is derived in which singularities of momentum transfer as well as singularities in the vicinity of the energy surface appear in explicit form. The derivation involves analytic continuation of the Coulomb  $t$ -matrix from the domain of negative energy, in which its singularities have already been explicitly extracted, into the domain of positive energy. Here the matrix is found to have additional singularities,

associated with its non-Bornian terms and appearing where the pole of the two-particle free resolvent intersects Coulomb singularities as well as where the poles of two free resolvents intersect. The matrix is found to have a discontinuity at zero energy, a special point in the Coulomb attraction field, and the magnitude of the  $t^C$  jump at this point is calculated asymptotically with the aid of the Riemann-Lebesgue lemma. References 21: 11 Russian, 10 Western.

**Reparametrization of Paths in Path Integral on Finite-Dimensional Manifold**

18620005c Moscow *TEORETICHESKAYA I*

*MATEMATICHESKAYA FIZIKA* in Russian

Vol 75 No 3, Jun 88 (manuscript received 21 Jul 86,

after completion 9 Jul 87) pp 403-415

[Article by S. N. Storchak, Institute of High-Energy Physics]

[Abstract] Reparametrization of paths in the path integral which represents the solution to the Schroedinger equation in imaginary time on a give n-dimensional manifold is analyzed by methods of random-process theory. Definition of a path integral in an  $R^n$ -space and then on a manifold is followed by reparametrization in it involving transformation of a random process such as a Markov process with appropriate constraints by random interchange of times, such a process being described by a stochastic differential equation. The reparametrization is repeated in standard symbolic notation, in which a path integral is comparable with the kernel of the evolution operator including a generatrix, and the resulting expression for the reparametrization Jacobian indicates that the measure is not invariant. The author thanks B. A. Abruzov, A. I. Oksak, and V. V. Smirnova for discussion and helpful suggestions. References 29: 7 Russian, 22 Western.

UDC 519.6:517.968

**Stability of Solution of Integral Equation of First Kind for Limited and Compact Sets**

18620102b Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 29 No 1, Jan 89 (manuscript received 10 Mar 88) pp 15-25

[Article by Yu. L. Gaponenko and S. L. Logunov, Moscow]

[Abstract] One of the principal and widely applied concepts of the modern theory of equations of the first kind is the theorem of stability of a solution in a compact set of functions. This article proposes a new approach to the problem of stability of solution of an equation of the first kind. A distinguishing feature of this approach is that two stages are involved. First an evaluation is made of weak stability of the solution in a limited (slightly compact) set in the space  $L_2$ . This evaluation is written in so-called "weak norm" terms. Then with transition to a narrower class of highly compact sets the "weak norm" evaluation is transformed into a similar "strong norm" evaluation. If information is lacking on whether the sought-for solution belongs to a highly compact set, from the "weak norm" evaluation it is easy to obtain a whole series of evaluations of different linear functionals of the desired solution. The Hilbert-Schmidt and Volterra

equations as applicable to this problem are examined in detail. References 17: 16 Russian, 1 Western.

UDC 519.6:535.4

**Application of Finite-Element Method to Problem of Wave Propagation Through Irregular Waveguide**

18620027 Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 28 No 8, Aug 88 (manuscript received 19 Jun 86, after revision 1 Feb 88) pp 1202-1209

[Article by A. S. Ilinskiy and A. F. Kadomtseva, Moscow]

[Abstract] An approximate solution to the problem of wave propagation through an irregular waveguide is obtained by the method of finite elements with a Hermitian basis. A planar waveguide of finite width and infinite length is considered, its filler including a slug whose dielectric permittivity is a smoothly continuous function of both longitudinal and transverse coordinates between two semiinfinitely long segments made each of a homogeneous but different dielectric material so that the waveguide becomes a partly regular one. The thus obtained approximate reflection and transmission coefficients for normal waves in such a waveguide are analytically shown to converge to the exact ones. References 4: Russian.

10

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